RFTA RIO GRANDE TRAIL
CORRIDOR STANDARDS

July 2019

GLENWOOD SPRINGS
Rio Grande Trail
RFTA
TO ASPEN

RFTA
ROARING FORK TRANSPORTATION AUTHORITY

Prepared for

Roaring Fork Transportation Authority

Prepared by

SEH and DHM Design

Table of Contents

List of Figures

Introduction

This first edition of the Rio Grande Trail Corridor Standards has been developed to establish a benchmark for quality, character, and materials along the RFTA-owned and managed reaches of the trail. The manual reflects the priority details and conditions as identified by RFTA staff and is not intended to be comprehensive in coverage of all possible improvement activities in the corridor.

The contents of this document reflect a compilation of a variety of information and details used in prior RFTA projects as well as standards from relevant public agencies. In some cases, new information has been developed to illustrate a specific condition. Where information has been referenced from prior RFTA projects or from public agency standards, the original authors of that information have been credited.

Until the development of this document, no single reference for details and implementation standards was available for the corridor. These guidelines and standards have been compiled to achieve the following objectives:

- Promote consistent construction practices and methodologies for projects in the corridor.
- Provide clarity, internally and externally to RFTA, in expectations for improvements to the corridor.
- Encourage a cohesive and identifiable character of materials and details.
- Establish clear expectations for private or municipal improvements or disturbances in the corridor (eg. new driveway or road crossings).
- Support the overarching goals of the Comprehensive Plan for the Aspen Branch of the Denver and Rio Grande Western Railroad Corridor (Comp. Plan).

A. Purpose and Use of This Manual

This manual is intended to be the initial reference for use in the planning, design, detailing, management and stewardship of the corridor facilities and amenities; it should be amended and expanded over time and as necessary to meet RFTA's needs. It is intended to act as a starting point for RFTA staff and outside consultant disciplines when considering specific project impacts or improvements to the corridor.

Novel project needs or physical conditions will likely require the development of additional, site-specific details and specifications to provide a fully constructible document package. Individual site conditions, including elements not described in this manual and specific geotechnical requirements, will require modification of existing detail or creation of new details. This document is not intended to be a substitute for competent, professional engineering or design; rather it is a resource for typical standards and benchmarking of project-specific information. Additionally, permitting or other documentation required by governing jurisdictions or funding sources will likely necessitate specific drawings and specifications for a given project.

Other applicable standards that inform this document and may be used for development of details and

specifications not contained in this manual include:

- CDOT M&S Standard Plans and Specifications - https://www.codot.gov/programs/bikeped/design-policy.html
- MUTCD - https://mutcd.fhwa.dot.gov/
- AASHTO Bike Facilities Guide - http://imentaraddod.com/wp-content/uploads/2017/07/AASHTO-GBF-4-2012-bicycle.pdf
- FHWA – FTA: Policy Statement on Bicycle and Pedestrian Accommodation Regulations and Recommendations - https://www.fhwa.dot.gov/environment/bicycle_pedestrian/guidance/policy_accom.cfm

B. Rio Grande Trail Corridor Description

The Rio Grande Trail stretches 42 miles from Glenwood Springs to Aspen. RFTA owns the corridor from Glenwood Springs to Woody Creek and manages the Rio Grande Trail from Glenwood Springs to Emma. Pitkin County manages the trail from Emma to Aspen via easements, with the City of Aspen owning and maintaining the last 0.6 miles through Aspen. This manual applies to the reach of the trail from Glenwood Springs to Emma.

The existing corridor consists of a 10'-wide asphalt trail, with soft shoulders of recycled asphalt gravels on one or both sides along much of the trail. Additionally, the corridor includes short sections of road base / CL 6 or single track trails separate from the paved trail (but within the corridor). The corridor width varies, but typically the ROW is 100' wide. The corridor also contains trailhead amenities (eg. signage, bike maintenance stations); on-trail facilities such as picnic tables, trash/recycling, shade structures, restrooms, and pet waste stations; interpretive, directional, and regulatory signage; park spaces (eg. DeRail Park in Carbondale); art installations; and gardens. The corridor includes retaining walls, fences, access control devices, drainage structures/ditches, and several bridges. The unpaved area of the corridor is primarily native vegetation, with some garden areas. Automatic irrigation exists in relatively small areas of the corridor; otherwise the corridor is largely un-irrigated. The trail crosses through several communities, with many public and private road/drive crossings both signalized and un-controlled, and provides access to public parks, trails, and open space along its route. The corridor is subject to certain utility easements and conservation covenants.

The trail is intended for use by pedestrians, cyclists, and equestrians. Class I and Class II E-bikes are allowed on the RFTA-managed reach of the RGT, between Two Rivers Park in Glenwood Springs and Emma Road in Basalt. Other motorized vehicles are prohibited from use on the trail with the exception of first responders, approved mobility assistance devices, RFTA maintenance equipment and vehicles, RFTA-employed contractors, and approved agricultural users.

The corridor may be used for other transit modalities in the future; as such the existing railroad line and grade must be maintained. Other improvements (e.g. road and driveway crossings) will we designed to accommodate the railroad line and grade.

Trail improvements, and project work impacting the trail/corridor are to be designed and implemented in a manner consistent with the spirit of this manual and consistent with the guidance provided in the current edition of the Comp. Plan.

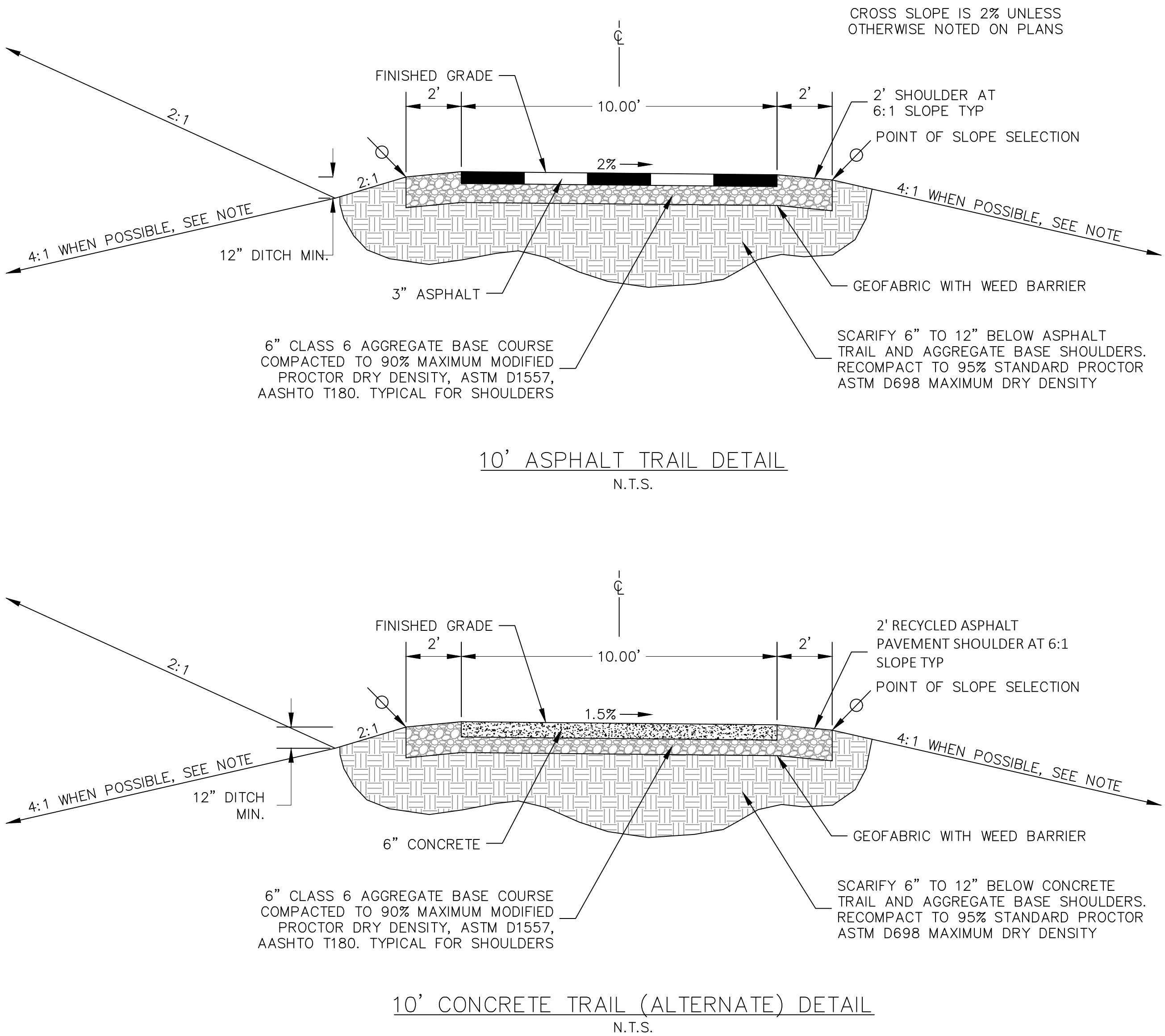
C. Source and Use of The Contents of This Manual

This manual was developed using original details, excerpts from relevant public trails manuals, and project details as provided by RFTA staff. The authorship of the reference manuals and detail content is attributed with each individual reference. These details are intended to illustrate intent, character, materials, and standard dimensions, or are representations of nationally accepted standards, but are not to be considered a substitute for competent professional design and engineering. Reference details may not be directly used in whole or in part in project technical drawings.

1 Typical Cross Sections and Layout Standards

1.1 Asphalt and Concrete Pavement

Asphalt is the standard surface material for the 10' wide, paved trail. Concrete may be used in areas of heavy loading/turning or when crossing existing concrete surfacing. Asphalt surfacing is to conform to SX 75(52-28) Grading. Concrete is to be CDOT Class D.



NOTES:

1. MAINTAIN MINIMUM 3' CLEAR ZONE FROM THE EDGE OF PAVEMENT, FREE OF SIGNS, VEGETATION, ETC.
2. A SUITABLE BARRIER SUCH AS A RAILING OR FENCE SHOULD BE PROVIDED AT THE TOP OF THE SLOPE. SPECIFICALLY, BARRIERS SHOULD BE PLACED TO SEPARATE SHARED USE PATHS FROM DROP-OFFS UNDER THE FOLLOWING CONDITIONS:
   - SLOPES 3:1 OR STEEPER, WITH A DROP OF 6 FEET OR GREATER
   - SLOPES 2:1 OR STEEPER, WITH A DROP OF 4 FEET OR GREATER
   - SLOPES 1:1 OR STEEPER, WITH A DROP OF 1 FEET OR GREATER
   - SLOPES 3:1 OR STEEPER, ADJACENT TO A PARALLEL WATER HAZARD, ROADWAY, OR OTHER OBVIOUS HAZARD

Figure 1.1 - Typical Asphalt and Concrete Trail Cross-Sections
Detail provided by SEH

1.2 Soft Surface Trails

Road Base Paving / Class 6 ABC - Apply Class 6 ABC over compacted subgrade (remove large roots and organic material from surface of sub-grade.) Install Class 6 ABC to a depth of 4" in two equal lifts, moisten and compact. Compact with plate or vibratory roller.

Recycled Asphalt Paving (RAP) - Standard material for typical 2' wide shoulder. RAP is also appropriate for secondary trails, connections to adjacent trail or public lands uses where traffic density is moderate and vehicular/equipment access is not required. RAP to be as regionally available; typically well-graded, 3/4" minus with no material exceeding 1". Place over compacted native earth to a depth of 4" in two equal lifts, level with or maximum 1/4" below the edge of asphalt. Rake material to provide even running surface; compact via plate or vibratory roller to consolidate material and reduce erosion/migration.

Natural Soil - Typical surface material for tertiary trails, including single track, public lands access, and locations where primitive trail character is preferred and use densities are relatively low. Typically employed as a single-track , 18"-30" wide, of compacted native soil. Prepare trail bed by removing existing vegetation, surface roots and rocks, and subsurface roots to a depth of 6". Loosen and rake soil to achieve a consistent trail bed. Compact with plate, jumping jack, or hand tamp. User densities that suggest a trail wider than 30" are more appropriately surfaced with RAP or Class 6 ABC.

1.3 Trails Horizontal and Vertical Layouts

Grades, sight lines, vertical and horizontal clearance are to comply with the standards set forth in the AASHTO Guide to Bicycle Facilities, 4th Edition-2012. The following pages are excerpted from Chapter 5, Design of Shared Use Paths.

RGT posted maximum speed is 20 MPH.

5.2.4 Design Speed

Design speed is a selected speed used to determine various geometric features of the shared use path. Once the design speed is selected, all pertinent path features should be related to it to obtain a balanced design. In most situations, shared use paths should be designed for a speed that is at least as high as the preferred speed of the fastest common user. The speed a path user travels is dependent on several factors, including the physical condition of the user; the type and condition of the user's equipment; the purpose and length of the trip; the condition, location, and grade of the path; the prevailing wind speed and direction; and the number and types of other users on the path.

There is no single design speed that is recommended for all paths. When selecting an appropriate design speed for a specific path, planners and designers should consider several factors including the context of the path, the types of users expected, the terrain the path runs through, prevailing winds, the path surface, and other path characteristics. The following examples help to illustrate these factors:

- **Types of Users and Context.** An urban path with a variety of users and frequent conflicts and constraints may be designed for lower speeds than a rural path with few conflicts that is primarily used by recreational bicyclists (potentially including recumbent bicyclists, whose 85th percentile speed is 18 mph [29 km/h]).
- **Terrain.** A path in fairly hilly terrain should be designed for a higher speed.
- **Path Surface.** Bicyclists tend to ride slower on unpaved paths, so a lower design speed may be used.

Figure 1.2 - Trail Layout- Design Speed.
Excerpted from AASHTO Guide to Bicycle Facilities, 4th Edition-2012. Page 5-12.
Original content by AASHTO

In street and highway design, design speeds are generally selected in 5 mph or 10 km/h increments; which are based on the approximate 85th percentile speed range on various types of roadways of 20 mph (30 km/h) to 75 mph (120 km/h) or higher. On paths, the range of speeds is much smaller, ranging as low as 12 mph (19 km/h) to 30 mph (50 km/h). Therefore, design speeds for paths can be selected in 2 mph (3 km/h) increments. Design criteria for geometric features in this document are provided in 2 mph (3 km/h) increments for the slower end of the scale (design speeds between 12 mph [19 km/h] and 20 mph [32 km/h]). For design speeds above 20 mph (32 km/h), 5 mph (8 km/h) increments are used.

The following guidance and the aforementioned consideration of various factors should guide the selection of an appropriate design speed:

- For most paths in relatively flat areas (grades less than 2 percent), a design speed of 18 mph (30 km/h) is generally sufficient, except on inclines where higher speeds can occur. The design speed should not be lower, except in rare circumstances where the context and user types support a lower speed.

- In areas with hilly terrain and sustained steeper grades (6 percent or greater), the appropriate design speed should be selected based on the anticipated travel speeds of bicyclists going downhill. In all but the most extreme cases, 30 mph (48 km/h) is the maximum design speed that should be used.

Lower speeds can reduce the likelihood for crashes at approaches to crossings or conflict points by allowing the path user to better perceive the crossing situation or potential conflict. It is important to give the bicyclist adequate warning (either through signs or by maintaining adequate sight lines) prior to areas of the pathway where lower design speeds are employed. See Section 5.4.2 for guidance on warning signs.

Geometric design and traffic control devices can be used to reduce path users' speed. Speeds can be reduced by geometric features such as horizontal curvature. Effectiveness of speed control through design is limited if bicyclists can veer off a path to "straighten out" curves, and speed limit signs on paths may not be effective, as most bicyclists do not use speedometers.

5.2.5 Horizontal Alignment

The typical adult bicyclist is the design user for horizontal alignment. The minimum radius of horizontal curvature for bicyclists can be calculated using two different methods. One method uses "lean angle," and the other method uses superelevation and coefficient of friction. As detailed below, in general, the lean angle method should be used in design, although there are situations where the superelevation method is helpful.

Calculating Minimum Radius Using Lean Angle

Unlike an automobile, a bicyclist must lean while cornering to prevent falling outward due to forces associated with turning movements. Most bicyclists usually do not lean drastically; 20 degrees is considered the typical maximum lean angle for most users (*10*). Assuming an operator who sits straight in the seat, Table 5-1 shows an equation that can determine the minimum radius of curvature for any given lean angle and design speed.

Figure 1.3 - Trail Layout- Design Speed; Horizontal Alignment
Excerpted from AASHTO Guide to Bicycle Facilities, 4th Edition-2012. Page 5-13.
Original content by AASHTO

Table 5-1. Minimum Radius of Curvature Based on Lean Angle

U.S. Customary		
$R = \frac{0.067V^2}{\tan\theta}$		
where:		
R	=	minimum radius of curvature (ft)
V	=	design speed (mph)
θ	=	lean angle from the vertical (degrees)

Metric		
$R = \frac{0.0079V^2}{\tan\theta}$		
where:		
R	=	minimum radius of curvature (m)
V	=	design speed (km/h)
θ	=	lean angle from the vertical (degrees)

As described in Section 5.1.1, shared use paths should meet accessibility guidelines, which restrict the steepness of cross slopes. One percent slopes are recommended on shared use paths where practical, because they are easier to navigate for people using wheelchairs. In most cases the lean angle formula should be used when determining the minimum radius of a horizontal curve, due to the need for relatively flat cross slopes and the fact that bicyclists lean when turning (regardless of their speed or the radius of their turn). The curve radius should be based upon various design speeds of 18 to 30 mph (29 to 48 km/h) and a desirable maximum lean angle of 20 degrees. Lower design speeds of 12 to 16 mph (19 to 26 km/h) may be appropriate under some circumstances (e.g., where environmental or physical constraints limit the geometrics). Minimum radii of curvature for a paved path can be selected from Table 5-2.

Table 5-2. Minimum Radii for Horizontal Curves on Paved, Shared Use Paths at 20-Degree Lean Angle

U.S. Customary		Metric	
Design Speed (mph)	Minimum Radius (ft)	Design Speed (km/h)	Minimum Radius (m)
12	27	19	8
14	36	23	11
16	47	26	15
18	60	29	18
20	74	32	22
25	115	40	35
30	166	48	50

Calculating Minimum Radius Using Superelevation

The second method of calculating minimum radius of curvature negotiable by a bicycle uses the design speed, the superelevation rate of the pathway surface, and the coefficient of friction between the bicycle tires and the surface, as shown in Table 5-3:

Figure 1.4 - Trail Layout- Horizontal Alignment
Excerpted from AASHTO Guide to Bicycle Facilities, 4th Edition-2012. Page 5-14.
Original content by AASHTO

Table 5-3. Minimum Radius of Curvature Based on Superelevation

U.S. Customary		
$R = \dfrac{V^2}{15\left(\dfrac{e}{100} + f\right)}$		
where:		
R	=	minimum radius of curvature (ft)
V	=	design speed (mph)
e	=	rate of bikeway superelevation (percent)
f	=	coefficient of friction

Metric		
$R = \dfrac{V^2}{127\left(\dfrac{e}{100} + f\right)}$		
where:		
R	=	minimum radius of curvature (m)
V	=	design speed (km/h)
e	=	rate of bikeway superelevation (percent)
f	=	coefficient of friction

The coefficient of friction depends upon speed, surface type and condition, tire type and condition, and whether the surface is wet or dry. Friction factors used for design should be selected based upon the point at which turning forces or perceived lack of surface traction causes the bicyclist to recognize a feeling of discomfort and instinctively act to avoid higher speed. Extrapolating from values used in highway design, design friction factors for paved shared use paths can be assumed to vary from 0.34 at 6 mph (10 km/h) to 0.21 at 30 mph (48 km/h). On unpaved surfaces, friction factors should be reduced by 50 percent to reduce the likelihood of crashes.

Calculating minimum radius based on superelevation may be useful on unpaved paths, where bicyclists may be hesitant to lean as much while cornering due to the perceived lack of traction. In these situations, the superelevation formula should be used with appropriate friction factors for unpaved surfaces. Calculating minimum radius based on superelevation may also be useful on paved paths intended for bicycle use only, allowing higher design speeds to be accommodated on relatively sharp curves with cross slopes (superelevation) up to 8 percent.

When a radius is smaller than that needed for an 18 mph (29 km/h) design speed, standard turn or curve warning signs (W1 series) should be installed in accordance with the MUTCD (*7*). Smaller radius curves are typically used when there are constrained site conditions, topographic challenges, or a desire to reduce path user speeds. The negative effects of sharper curves can also be partially offset by widening the pavement through the curves.

5.2.6 Cross Slope

As previously described, shared use paths must be accessible to people with disabilities. Shared use paths located adjacent to roadways essentially function as sidewalks, and therefore should follow PROWAG (*13*), which requires that cross slopes not exceed 2 percent. Until the specific regulations concerning shared use paths are completed (*14*), paths in independent rights-of-way should be designed according to *ANPRM on Shared Use Paths* (*12*), which also requires that cross slopes not exceed 2 percent. As described in the previous section, 1 percent cross slopes are recommended on shared use paths, to better accommodate people with disabilities and to provide enough slope to convey surface drainage in most situations. A cross-section that provides a center crown with no more than 1 percent in each direction may also be used.

Figure 1.5 - Trail Layout- Horizontal Alignment; Cross-Slope
Excerpted from AASHTO Guide to Bicycle Facilities, 4th Edition-2012. Page 5-15.
Original content by AASHTO

Because this guide recommends a relatively flat cross slope of 1 percent, and because horizontal curvature can be based on a 20-degree lean angle, superelevation for horizontal curvature is not needed. Since superelevation is not needed for horizontal curvature, cross slopes can follow the direction of the existing terrain. This practice enables the designer to better accommodate surface drainage and lessen construction impacts.

If cross slopes steeper than 2 percent are needed, they should be sloped to the inside of horizontal curves regardless of drainage conditions. Steeper cross slopes (up to 5 percent) may occasionally be desirable on unpaved shared use paths to reduce the likelihood of puddles caused by surface irregularities and to allow increased superelevation to achieve smaller radii of curvature, as previously described in the subsection on horizontal alignment. In rare situations where a path is intended for bicycle use only (e.g., pedestrians are accommodated on a separate pathway) and does not need to meet accessibility guidelines, cross slopes between 5 and 8 percent can be used to allow for smaller minimum horizontal curve radii, as discussed above.

Cross slopes should be transitioned to connect to existing slopes, or to adjust to a reversal of predominant terrain slope or drainage, or to a horizontal curve in some situations. Cross slope transitions should be comfortable for the path user. A minimum transition length of 5 ft (1.5 m) for each 1 percent change in cross slope should be used.

5.2.7 Grade

The maximum grade of a shared use path adjacent to a roadway should be 5 percent, but the grade should generally match the grade of the adjacent roadway. Where a shared use path runs along a roadway with a grade that exceeds 5 percent, the sidepath grade may exceed 5 percent but must be less than or equal to the roadway grade. Grades on shared use paths in independent rights-of-way should be kept to a minimum, especially on long inclines. Grades steeper than 5 percent are undesirable because the ascents are difficult for many path users, and the descents cause some users to exceed the speeds at which they are competent or comfortable. In addition, because shared use paths are generally open to pedestrians, the allowable grades on paths are subject to the accessibility guidelines described in the *ANPRM on Shared Use Paths* (*12*). Grades on paths in independent rights-of-way should also be limited to 5 percent maximum. The ANPRM suggests that certain conditions such as physical constraints (existing terrain or infrastructure, notable natural features, etc.) or regulatory constraints (endangered species, the environment, etc.) may prevent full compliance with the 5 percent maximum grade. Refer to the U.S. Access Board website (www.access-board.gov) for up-to-date information regarding the accessibility provisions for shared-use paths covered by the Americans with Disabilities Act and the Architectural Barriers Act.

Options to mitigate excessive grades on shared use pathways include the following:

- Use higher design speeds for horizontal and vertical curvature, stopping sight distance, and other geometric features.
- When using a longer grade, consider an additional 4 to 6 ft (1.2 to 1.8 m) of width to permit slower bicyclists to dismount and walk uphill, and to provide more maneuvering space for fast downhill bicyclists.
- Install the hill warning sign for bicyclists (W7-5) and advisory speed plaque, if appropriate, per the MUTCD (*7*).

Figure 1.6 - Trail Layout- Cross-Slope; Grade
Excerpted from AASHTO Guide to Bicycle Facilities, 4th Edition-2012. Page 5-16.
Original content by AASHTO

- Provide signing that alerts path users to the maximum percent of grade as shown in the MUTCD (*7*).

- Exceed minimum horizontal clearances, recovery area, and/or protective railings.

- If other designs are not practicable, use a series of short switchbacks to traverse the grade. If this is done, an extra 4 to 6 ft (1.2 to 1.8 m) of path width is recommended to provide maneuvering space.

- Provide resting intervals with flatter grades, to permit users to stop periodically and rest.

Grades steeper than 3 percent may not be practical for shared use paths with crushed stone or other unpaved surfaces for both bicycle handling and drainage erosion reasons. Typically, grades less than 0.5 percent should be avoided, because they are not efficient in conveying surface drainage. Where paths are built in very flat terrain, proposed path grades can be increased to provide a gradually rolling vertical profile that helps convey surface drainage to outlet locations.

5.2.8 Stopping Sight Distance

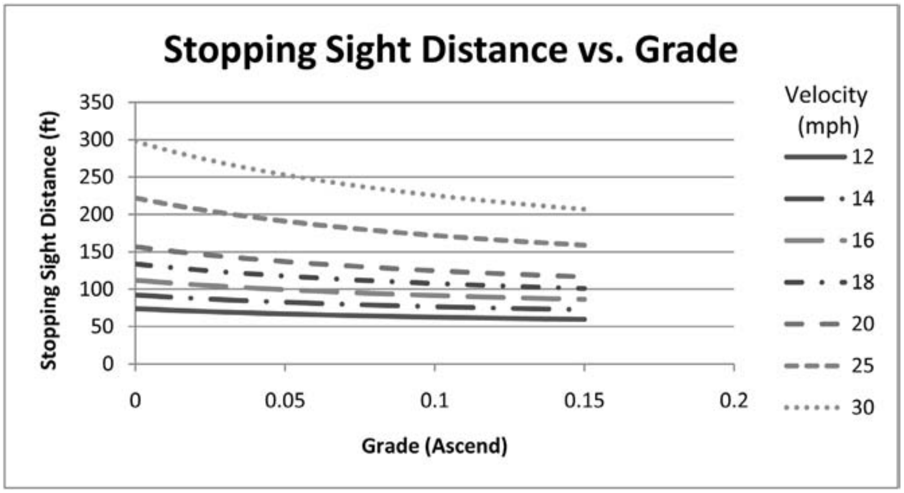
To provide path users with opportunities to see and react to unexpected conditions, shared use paths should be designed with adequate stopping sight distances. The distance needed to bring a path user to a fully controlled stop is a function of the user's perception and braking reaction times, the initial speed, the coefficient of friction between the wheels and the pavement, the braking ability of the user's equipment, and the grade. The coefficient of friction for the typical bicyclist is 0.32 for dry conditions. Figures 5-6 and 5-7 indicates the minimum stopping sight distance for various design speeds and grades based on a total perception and brake reaction time of 2.5 seconds and a coefficient of friction of 0.16 (Table 5-4), appropriate for wet conditions. Minimum stopping sight distance can also be calculated using the equation shown in Table 5-4.

Table 5-4. Minimum Stopping Sight Distance

U.S. Customary		
$S=\frac{V^2}{30(f \pm G)}+3.67V$		
where:		
S	=	stopping sight distance (ft)
V	=	velocity (mph)
f	=	coefficient of friction (use 0.16 for a typical bike)
G	=	grade (ft/ft) (rise/run)

Metric		
$S=\frac{V^2}{254(f \pm G)}+\frac{V}{1.4}$		
where:		
S	=	stopping sight distance (m)
V	=	velocity (km/h)
f	=	coefficient of friction (use 0.16 for a typical bike)
G	=	grade (m/m) (rise/run)

Figure 1.7 - Trail Layout- Grade; Stopping Sight Distance
Excerpted from AASHTO Guide to Bicycle Facilities, 4th Edition-2012. Page 5-17.
Original content by AASHTO



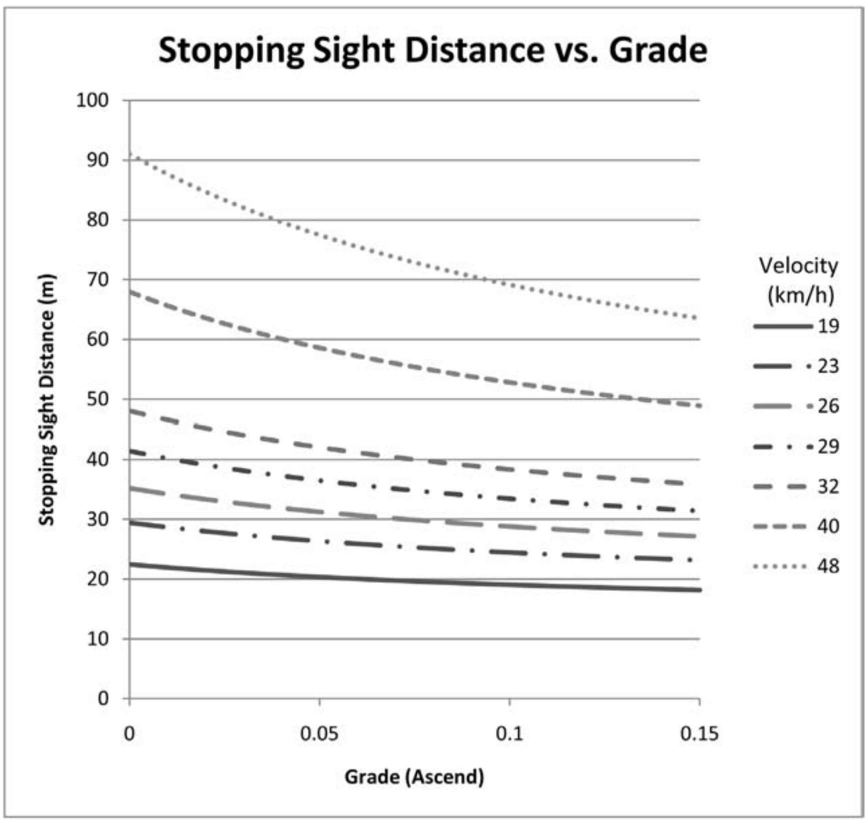
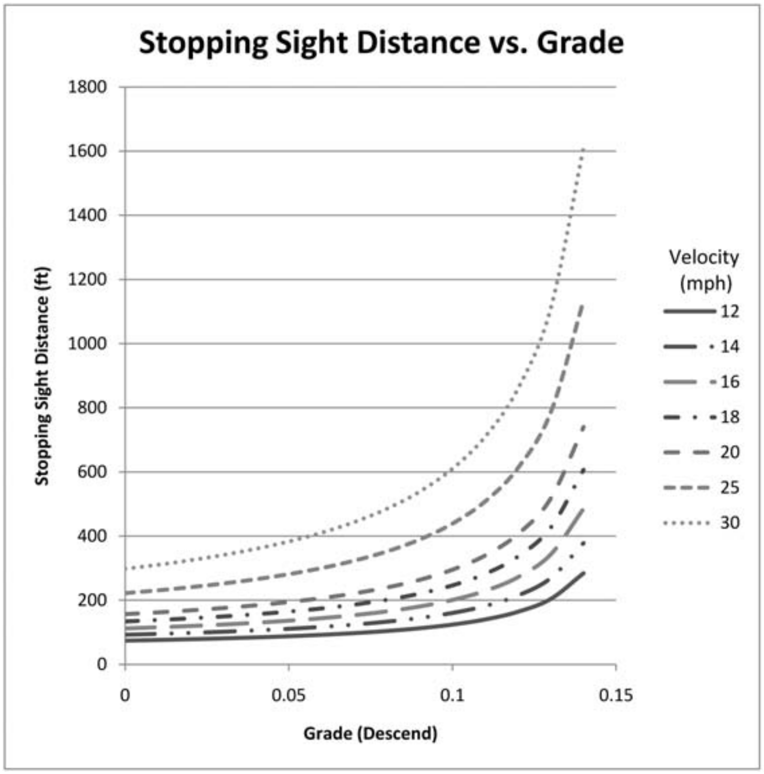


Figure 5-6. Minimum Stopping Sight Distance vs. Grades for Various Design Speeds—Ascending Climbing Grade

Figure 1.8 - Trail Layout- Stopping Sight Distance
Excerpted from AASHTO Guide to Bicycle Facilities, 4th Edition-2012. Page 5-18.
Original content by AASHTO



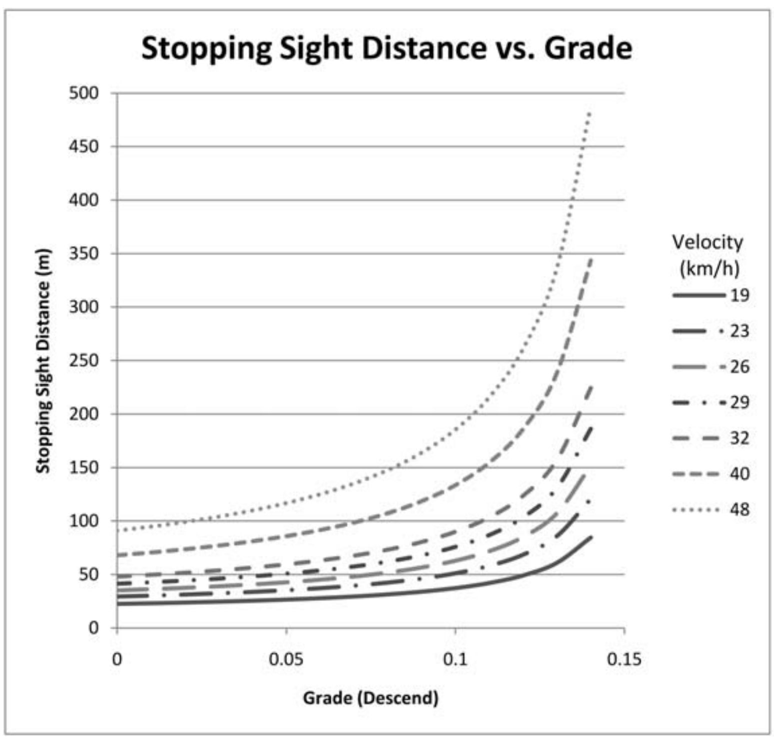


Figure 1.9 - Trail Layout- Stopping Sight Distance
Excerpted from AASHTO Guide to Bicycle Facilities, 4th Edition-2012. Page 5-19.
Original content by AASHTO

Research indicates that, under dry conditions, the coefficient of friction of various other path users range from 0.20 for inline skaters to 0.30 for recumbent bicyclists. If users with lower coefficients of friction such as inline skaters or recumbent bicyclists are expected to make up a relatively large percentage of path users, stopping sight distances should be increased. For two-way shared use paths, the sight distance in the descending direction, that is, where "G" is defined as negative, will control the design.

Figure 5-8 is used to select the minimum length of vertical curve needed to provide minimum stopping sight distance at various speeds on crest vertical curves. The eye height of the typical adult bicyclist is assumed to be 4.5 ft (1.4 m), and the object height is assumed to be 0 in. (0 mm) to recognize that impediments to bicycle travel exist at pavement level. The minimum length of vertical curve can also be calculated using the following equation as shown in Table 5-5.

Table 5-5. Length of Crest Vertical Curve to Provide Sight Distance

U.S. Customary		
$S<L \quad L=2S-\frac{200\left(\sqrt{h_1}+\sqrt{h_2}\right)^2}{A}$ $S<L \quad L=2S-\frac{AS^2}{100\left(\sqrt{2h_1}+\sqrt{2h_2}\right)^2}$		
where:		
L	=	minimum length of vertical curve (ft)
A	=	algebraic grade difference (percent)
S	=	stopping sight distance (ft)
h_1	=	eye height (4.5 ft for a typical bicyclist)
h_2	=	object height (0 ft)

Metric		
$S<L \quad L=2S-\frac{200\left(\sqrt{h_1}+\sqrt{h_2}\right)^2}{A}$ $S<L \quad L=2S-\frac{AS^2}{100\left(\sqrt{2h_1}+\sqrt{2h_2}\right)^2}$		
where:		
L	=	minimum length of vertical curve (m)
A	=	algebraic grade difference (percent)
S	=	stopping sight distance (m)
h_1	=	eye height (1.4 m for a typical bicyclist)
h_2	=	object height (0 m)

Figure 1.10 - Trail Layout- Stopping Sight Distance
Excerpted from AASHTO Guide to Bicycle Facilities, 4th Edition-2012. Page 5-20.
Original content by AASHTO

U.S. Customary

A	S = Stopping Sight Distance (ft)													
(%)	20	40	60	80	100	120	140	160	180	200	220	240	260	280	300
2												30	70	110	150
3								20	60	100	140	180	220	260	300
4						15	55	95	135	175	215	256	300	348	400
5					20	60	100	140	180	222	269	320	376	436	500
6				10	50	90	130	170	210	267	323	384	451	523	600
7				31	71	111	151	191	231	311	376	448	526	610	700
8			8	48	88	128	168	208	248	356	430	512	601	697	800
9			20	60	100	140	180	220	260	400	484	576	676	784	900
10			30	70	110	150	190	230	270	444	538	640	751	871	1000
11			38	78	118	158	198	238	278	489	592	704	826	958	1100
12		5	45	85	125	165	205	245	285	533	645	768	901	1045	1200
13		11	51	91	131	171	211	251	291	578	699	832	976	1132	1300
14		16	56	96	136	176	216	256	296	622	753	896	1052	1220	1400
15		20	60	100	140	180	220	260	300	667	807	960	1127	1307	1500
16		24	64	104	144	184	224	264	304	711	860	1024	1202	1394	1600
17		27	67	107	147	187	227	267	307	756	914	1088	1277	1481	1700
18		30	70	110	150	190	230	270	310	800	968	1152	1352	1568	1800
19		33	73	113	153	193	233	273	313	844	1022	1216	1427	1655	1900
20		35	75	115	155	195	235	275	315	889	1076	1280	1502	1742	2000
21		37	77	117	157	197	237	277	317	933	1129	1344	1577	1829	2100
22		39	79	119	159	199	239	279	319	978	1183	1408	1652	1916	2200
23		41	81	121	161	201	241	281	321	1022	1237	1472	1728	2004	2300
24	3	43	83	123	163	203	243	283	323	1067	1291	1536	1803	2091	2400
25	4	44	84	124	164	204	244	284	324	1111	1344	1600	1878	2178	2500

Shaded area represents S = L
Minimum length of vertical curve = 3 ft

Figure 5-8. Minimum Length of Crest Vertical Curve Based on Stopping Sight Distance

Other path users such as child bicyclists, hand bicyclists, recumbent bicyclists, and others have lower eye heights than a typical adult bicyclist. Eye heights are approximately 2.6 ft (0.85 m) for hand bicyclists and 3.9 ft (1.2 m) for recumbent bicyclists. When compared to the eye heights of typical bicyclists, these lower eye heights limit sight distance over crest vertical curves. However, since most hand bicyclists and child bicyclists travel slower than typical adult bicyclists, their needs are met by using the values in Figure 5-8. Recumbent bicyclists generally travel faster than typical upright bicyclists, so if they are expected to make up a relatively large percentage of path users, crest vertical curve lengths should be increased accordingly (operating characteristics of recumbent bicyclists are found in Chapter 3).

Figures 5-9, 5-10, and Table 5-6 indicate the minimum clearance that should be used for line-of-sight obstructions for horizontal curves. The lateral clearance (horizontal sight line offset or HSO) is obtained by using the table in Figure 5-9 with the stopping sight distance (Figure 5-6) and the proposed horizontal radius of curvature.

Path users typically travel side-by-side on shared use paths. On narrow paths, bicyclists have a tendency to ride near the middle of the path. For these reasons, and because of the higher likeli-

Figure 1.11 - Trail Layout- Stopping Sight Distance
Excerpted from AASHTO Guide to Bicycle Facilities, 4th Edition-2012. Page 5-21.
Original content by AASHTO

hood for crashes on curves, lateral clearances on horizontal curves should be calculated based on the sum of the stopping sight distances for path users traveling in opposite directions around the curve. Where this is not practical, consideration should be given to widening the path through the curve, installing a yellow center line stripe, installing turn or curve warning signs (W1 series) in accordance with the MUTCD (*7*), or a combination of these alternatives. See Sections 5.4.1 and 5.4.2 for more information about center line pavement markings and signs.

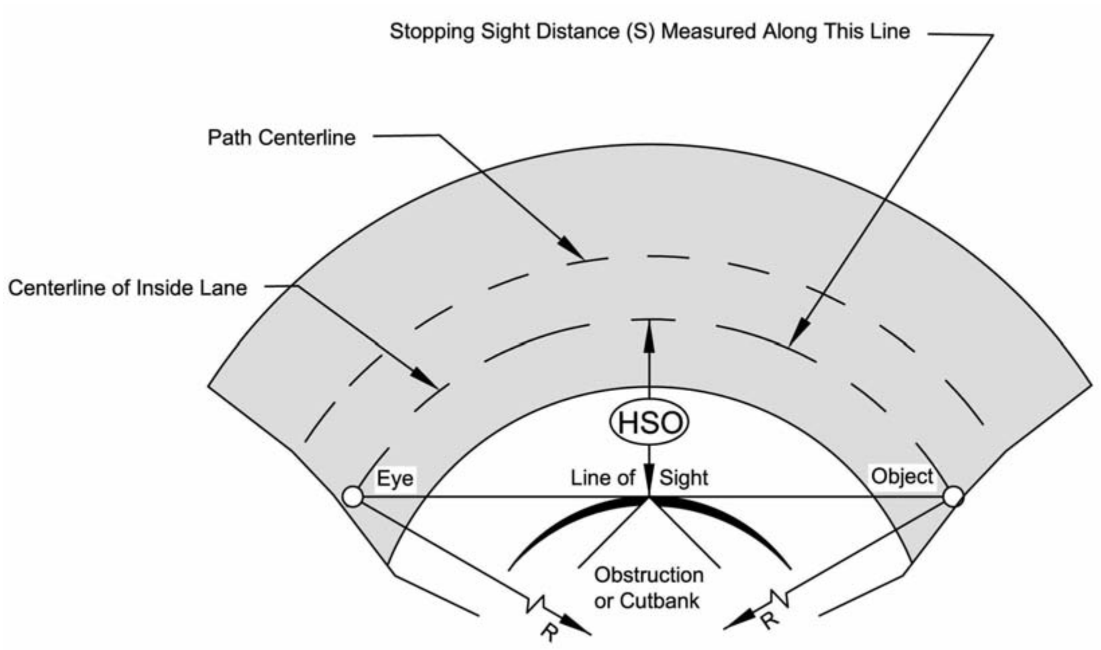


Figure 5-9. Diagram Illustrating Components for Determining Horizontal Sight Distance

Table 5-6. Horizontal Sight Distance

U.S. Customary		
$HSO = R\left[1 - \cos\left(\frac{28.65S}{R}\right)\right]$ $HSO = \frac{R}{28.65}\left[1 - \cos^{-1}\left(\frac{R - HSO}{R}\right)\right]$		
where:		
S	=	stopping sight distance (ft)
R	=	radius of centerline of lane (ft)
HSO	=	horizontal sightline offset, distance from centerline of lane to obstruction (ft)
Note: Angle is expressed in degrees; line of sight is 2.3 ft above centerline of inside lane at point of obstruction.		

Metric		
$HSO = R\left[1 - \cos\left(\frac{28.65S}{R}\right)\right]$ $HSO = \frac{R}{28.65}\left[1 - \cos^{-1}\left(\frac{R - HSO}{R}\right)\right]$		
where:		
S	=	stopping sight distance (m)
R	=	radius of centerline of lane (m)
HSO	=	horizontal sightline offset, distance from centerline of lane to obstruction (m)
Note: Angle is expressed in degrees; line of sight is 0.7 m above centerline of inside lane at point of obstruction.		

Figure 1.12 - Trail Layout- Stopping Sight Distance
Excerpted from AASHTO Guide to Bicycle Facilities, 4th Edition-2012. Page 5-23.
Original content by AASHTO

U.S. Customary

R (ft)	S = Stopping Sight Distance (ft) 20	40	60	80	100	120	140	160	180	200	220	240	260	280	300
25	2.0	7.6	15.9												
50	1.0	3.9	8.7	15.2	23.0	31.9	41.5								
75	0.7	2.7	5.9	10.4	16.1	22.8	30.4	38.8	47.8	57.4	67.2				
95	0.5	2.1	4.7	8.3	12.9	18.3	24.7	31.8	39.5	48.0	56.9	66.3	75.9	85.8	
125	0.4	1.6	3.6	6.3	9.9	14.1	19.1	24.7	31.0	37.9	45.4	53.3	61.7	70.6	79.7
155	0.3	1.3	2.9	5.1	8.0	11.5	15.5	20.2	25.4	31.2	37.4	44.2	51.4	59.1	67.1
175	0.3	1.1	2.6	4.6	7.1	10.2	13.8	18.0	22.6	27.8	33.5	39.6	46.1	53.1	60.5
200	0.3	1.0	2.2	4.0	6.2	8.9	12.1	15.8	19.9	24.5	29.5	34.9	40.8	47.0	53.7
225	0.2	0.9	2.0	3.5	5.5	8.0	10.8	14.1	17.8	21.9	26.4	31.3	36.5	42.2	48.2
250	0.2	0.8	1.8	3.2	5.0	7.2	9.7	12.7	16.0	19.7	23.8	28.3	33.1	38.2	43.7
275	0.2	0.7	1.6	2.9	4.5	6.5	8.9	11.6	14.6	18.0	21.7	25.8	30.2	34.9	39.9
300	0.2	0.7	1.5	2.7	4.2	6.0	8.1	10.6	13.4	16.5	19.9	23.7	27.7	32.1	36.7
350	0.1	0.6	1.3	2.3	3.6	5.1	7.0	9.1	11.5	14.2	17.1	20.4	23.9	27.6	31.7
390	0.1	0.5	1.2	2.1	3.2	4.6	6.3	8.2	10.3	12.8	15.4	18.3	21.5	24.9	28.5
500	0.1	0.4	0.9	1.6	2.5	3.6	4.9	6.4	8.1	10.0	12.1	14.3	16.8	19.5	22.3
565		0.4	0.8	1.4	2.2	3.2	4.3	5.7	7.2	8.8	10.7	12.7	14.9	17.3	19.8
600		0.3	0.8	1.3	2.1	3.0	4.1	5.3	6.7	8.3	10.1	12.0	14.0	16.3	18.7
700		0.3	0.6	1.1	1.8	2.6	3.5	4.6	5.8	7.1	8.6	10.3	12.0	14.0	16.0
800		0.3	0.6	1.0	1.6	2.2	3.1	4.0	5.1	6.2	7.6	9.0	10.5	12.2	14.0
900		0.2	0.5	0.9	1.4	2.0	2.7	3.6	4.5	5.6	6.7	8.0	9.4	10.9	12.5
1000		0.2	0.5	0.8	1.3	1.8	2.4	3.2	4.0	5.0	6.0	7.2	8.4	9.8	11.2

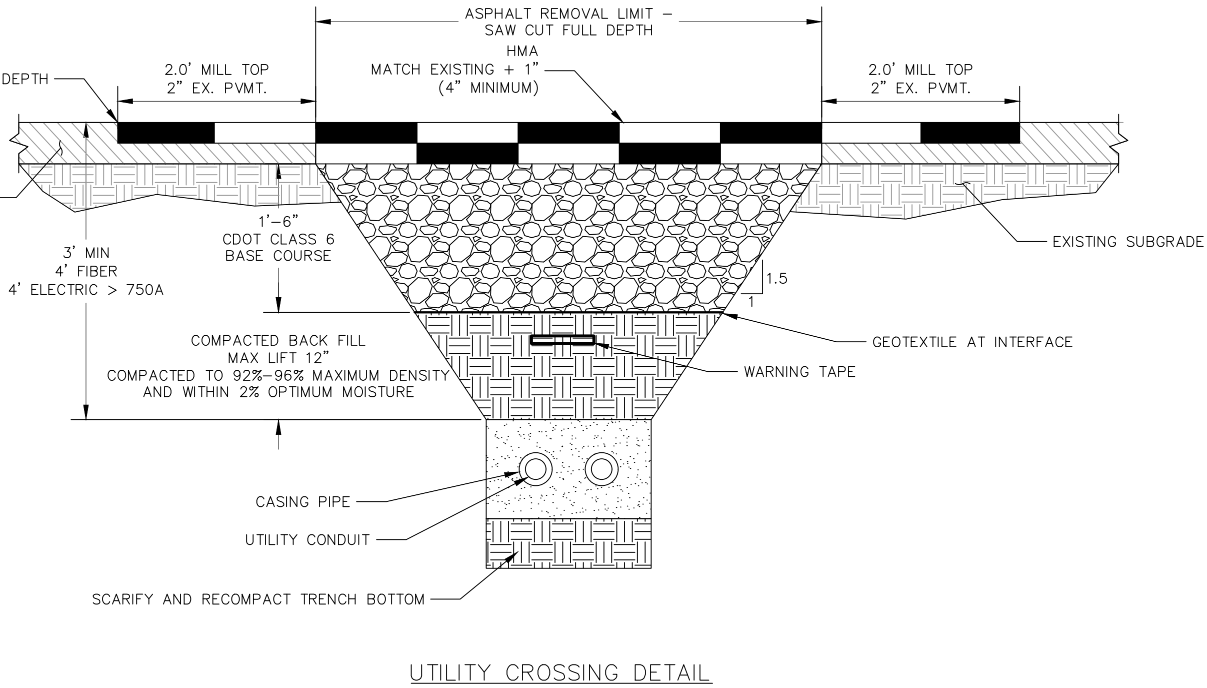
Metric

R (m)	S = Stopping Sight Distance (m) 10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100
10	1.2	2.7	4.6	6.8	9.3														
15	0.8	1.8	3.2	4.9	6.9	9.1	11.0	14.0											
20	0.6	1.4	2.4	3.8	5.4	7.2	9.2	11.0	14.0	16.0	19.0								
25	0.5	1.1	2.0	3.1	4.4	5.9	7.6	9.5	11.0	14.0	16.0	18.0	21.0	23.0					
50	0.3	0.6	1.0	1.6	2.2	3.0	3.9	5.0	6.1	7.4	8.7	10.0	12.0	13.0	15.0	17.0	19.0	21.0	23.0
75	0.2	0.4	0.7	1.0	1.5	2.0	2.7	3.4	4.1	5.0	5.9	6.9	8.0	9.2	10.0	12.0	13.0	15.0	16.0
100	0.1	0.3	0.5	0.8	1.1	1.5	2.0	2.5	3.1	3.8	4.5	5.2	6.1	7.0	7.9	8.9	10.0	11.0	12.0
125	0.1	0.2	0.4	0.6	0.9	1.2	1.6	2.0	2.5	3.0	3.6	4.2	4.9	5.6	6.3	7.2	8.0	8.9	9.9
150		0.2	0.3	0.5	0.7	1.0	1.3	1.7	2.1	2.5	3.0	3.5	4.1	4.7	5.3	6.0	6.7	7.5	8.3
175		0.2	0.3	0.4	0.6	0.9	1.1	1.4	1.8	2.2	2.6	3.0	3.5	4.0	4.6	5.1	5.8	6.4	7.1
200		0.1	0.3	0.4	0.6	0.8	1.0	1.3	1.6	1.9	2.2	2.6	3.1	3.5	4.0	4.5	5.0	5.6	6.2
225		0.1	0.2	0.3	0.5	0.7	0.9	1.1	1.4	1.7	2.0	2.3	2.7	3.1	3.5	4.0	4.5	5.0	5.5
250		0.1	0.2	0.3	0.5	0.6	0.8	1.0	1.2	1.5	1.8	2.1	2.4	2.8	3.2	3.6	4.0	4.5	5.0
275		0.1	0.2	0.3	0.4	0.6	0.7	0.9	1.1	1.4	1.6	1.9	2.2	2.6	2.9	3.3	3.7	4.1	4.5
300			0.2	0.3	0.4	0.5	0.7	0.8	1.0	1.3	1.5	1.8	2.0	2.3	2.7	3.0	3.4	3.8	4.2

Figure 5-10. Minimum Lateral Clearance (Horizontal Sightline Offset or HSO) for Horizontal Curves

Figure 1.13 - Trail Layout- Stopping Sight Distance
Excerpted from AASHTO Guide to Bicycle Facilities, 4th Edition-2012. Page 5-24.
Original content by AASHTO

1.4 Utility Crossing and Asphalt Patching



NOTES:

1. TRENCH MUST BE SLOPED AS AS SHOWN OR BRACED FOR THE SAFETY OF THE CONSTRUCTION WORKERS. TRENCHING WILL BE SUBJECT TO MOST RECENT CONFINED SPACE AND OSHA REGULATIONS.
2. EXISTING PAVEMENT SHALL BE SAWCUT AND REPLACED TO CREATE THE FULL DEPTH REPLACEMENT SHOWN. SAWCUTTING MUST OCCUR AFTER BACKFILLING AND BEFORE PAVING. 'T' PATCH MAY BE AN ACCEPTABLE ALTERNATIVE.
3. TRENCH BOTTOM MUST BE SCARIFIED AND RECOMPACTED AFTER EXCAVATION OR AFTER ANY DEWATERING ACTION TO ENSURE ADEQUATE SUPPORT OF UTILITY BEDDING.
4. CASING CAN BE OMITTED IF CROSSING IS >10' DEEP.

Figure 1.14 - Utility Crossing and Asphalt Patching Typical Section
Detail Provided by RFTA

1.5 Root Barrier

Root barrier is to be Deeproot Partners 18” depth mechanical root barrier model UB 18-2 or approved equal. Typical application is a linear installation at the outside edge of shoulder. Root barriers may be retrofitted in locations of existing trees or installed with new trees/pavement as needed. Root barriers are recommended when large trees exist or will be installed within 15’ of trail paving.

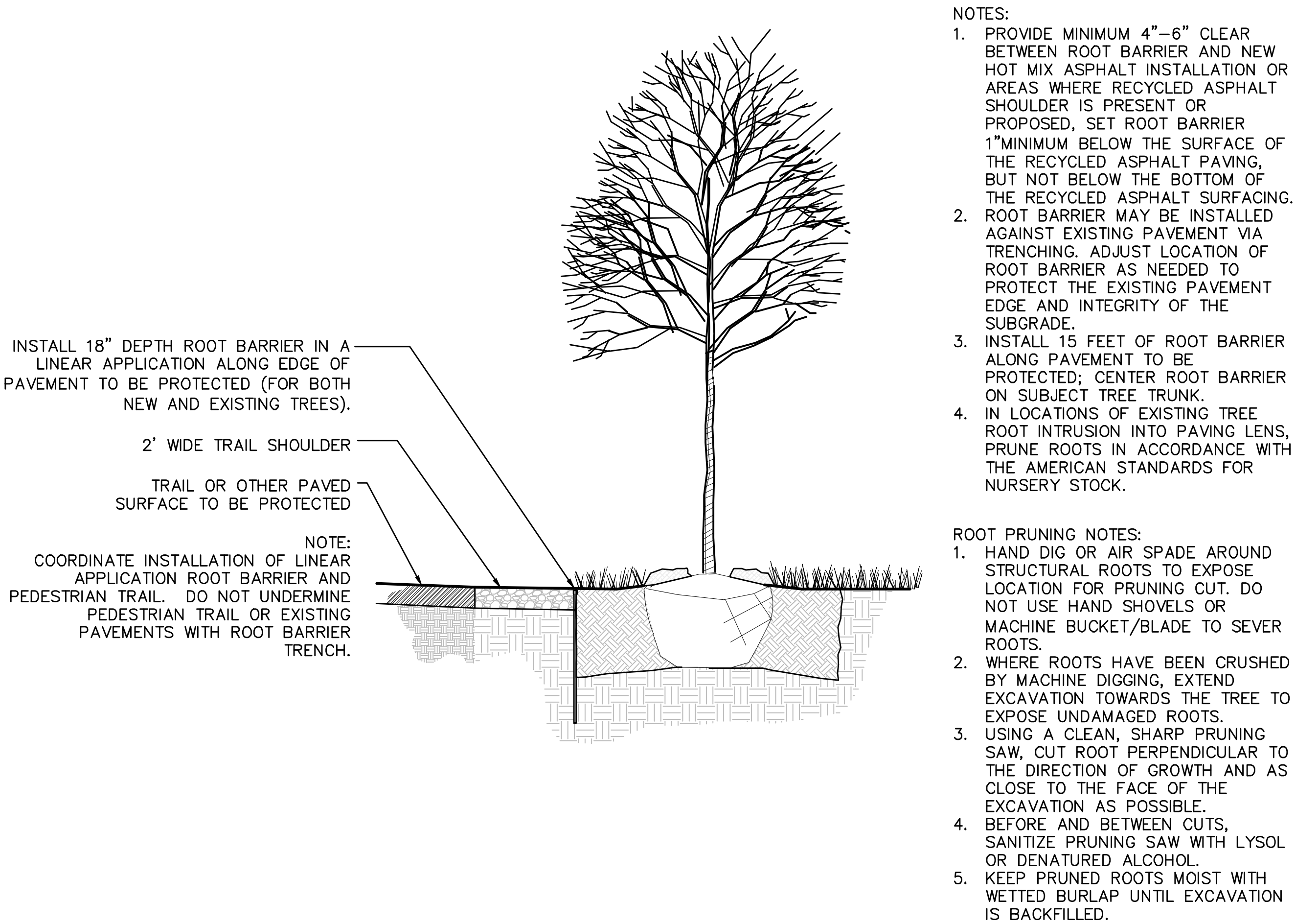


Figure 1.15 - Typical Root Barrier Application
Original detail by DHM Design

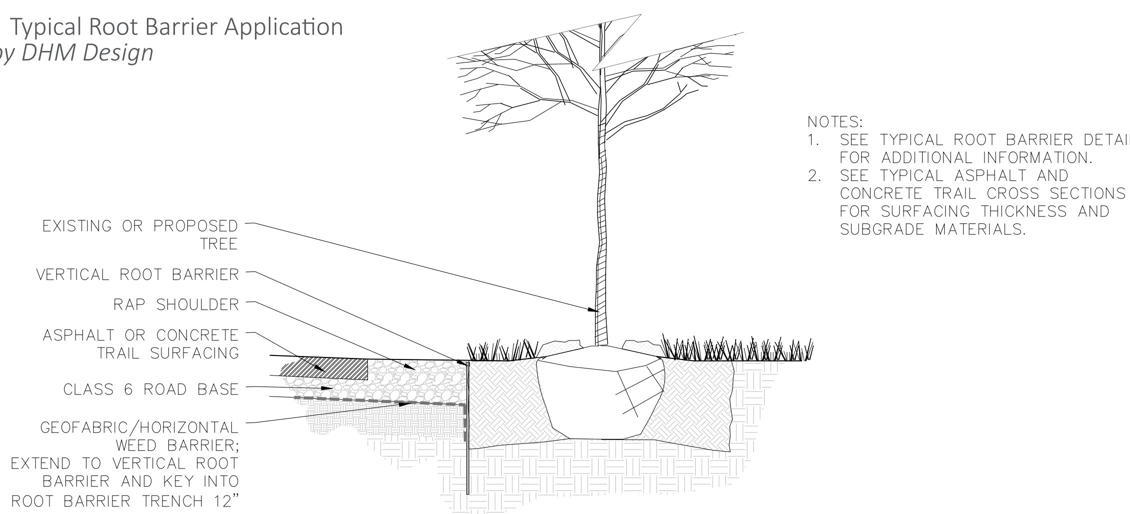


Figure 1.16 - Horizontal / Vertical Root Barrier Interface
Original detail by DHM Design

1.6 ADA Connections and Reference

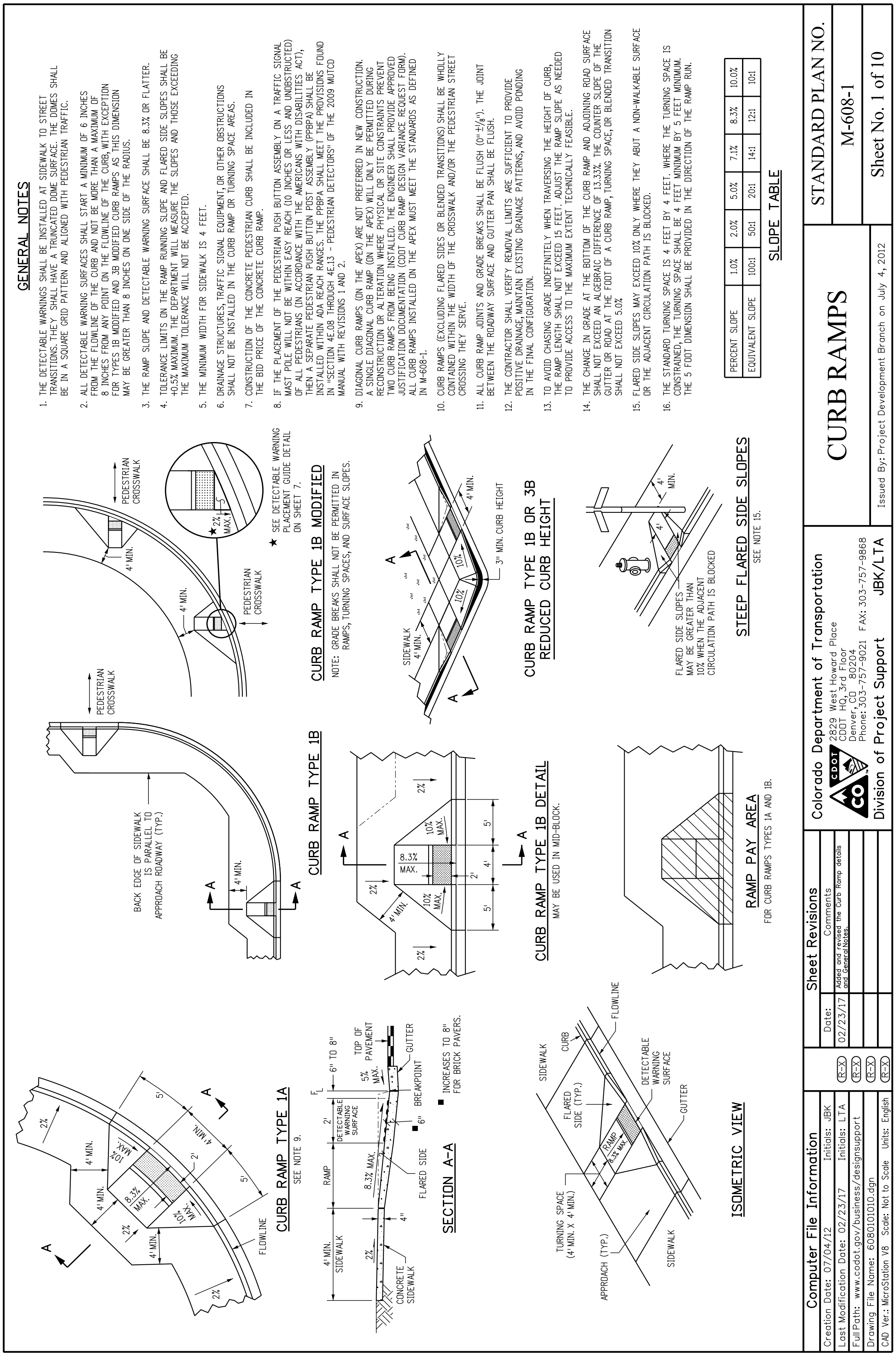


Figure 1.17 - Typical Curb Ramps
Original Detail CDOT Standard Plan No. M-608-1; 1 of 10

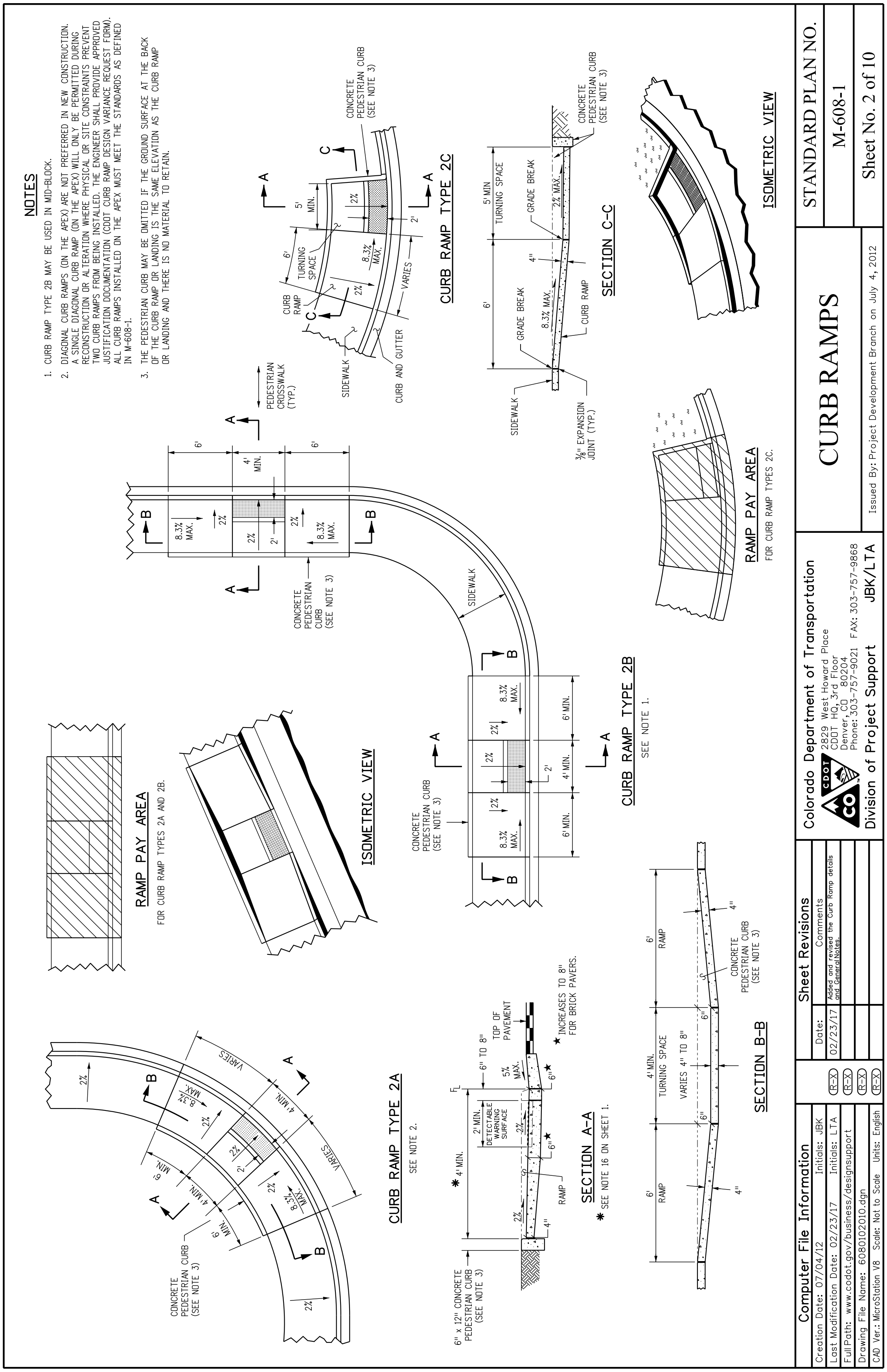


Figure 1.18 - Typical Curb Ramps
Original Detail CDOT Standard Plan No. M-608-1; 2 of 10

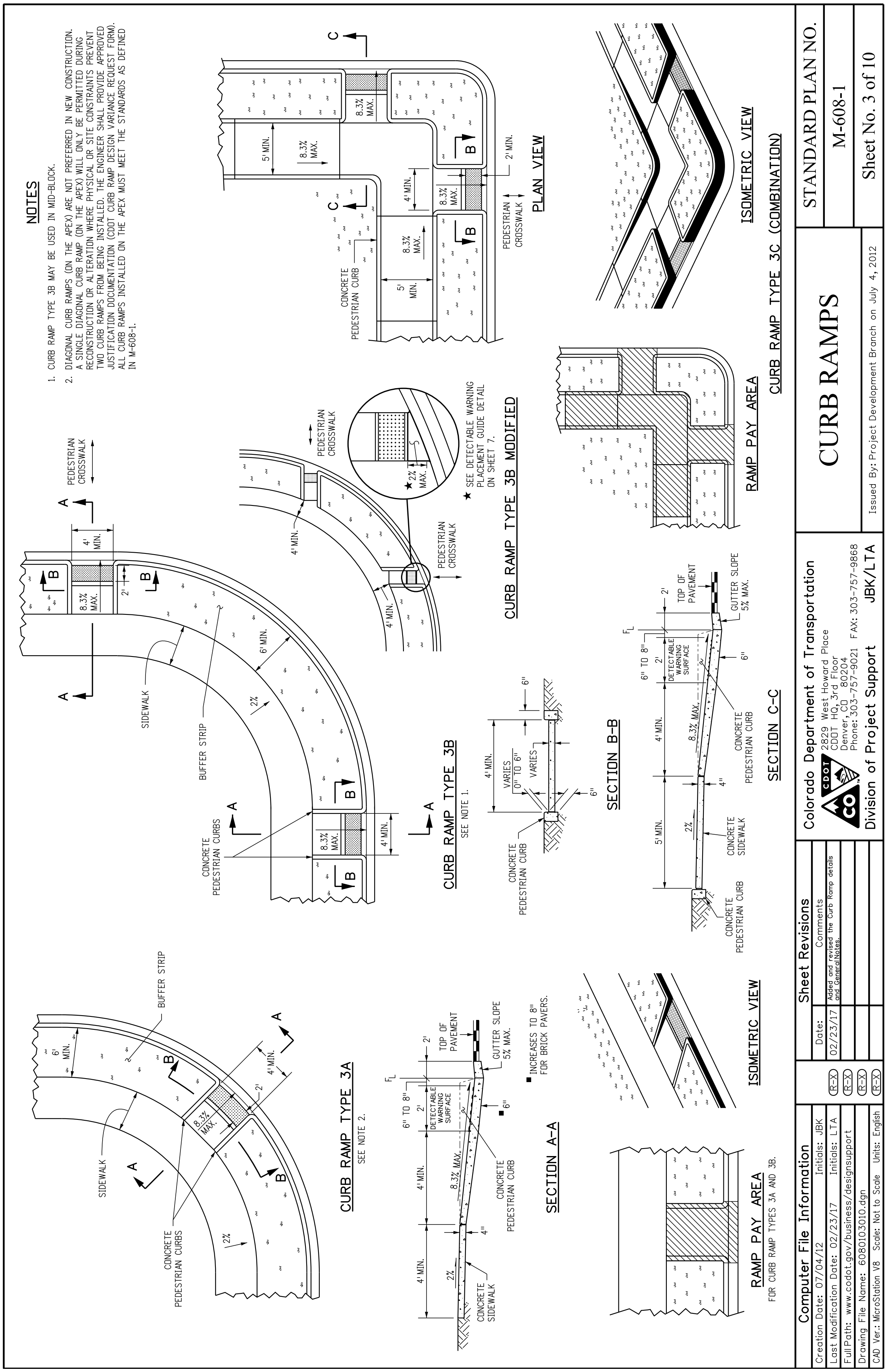


Figure 1.19 - Typical Curb Ramps
Original Detail CDOT Standard Plan No. M-608-1; 3 of 10

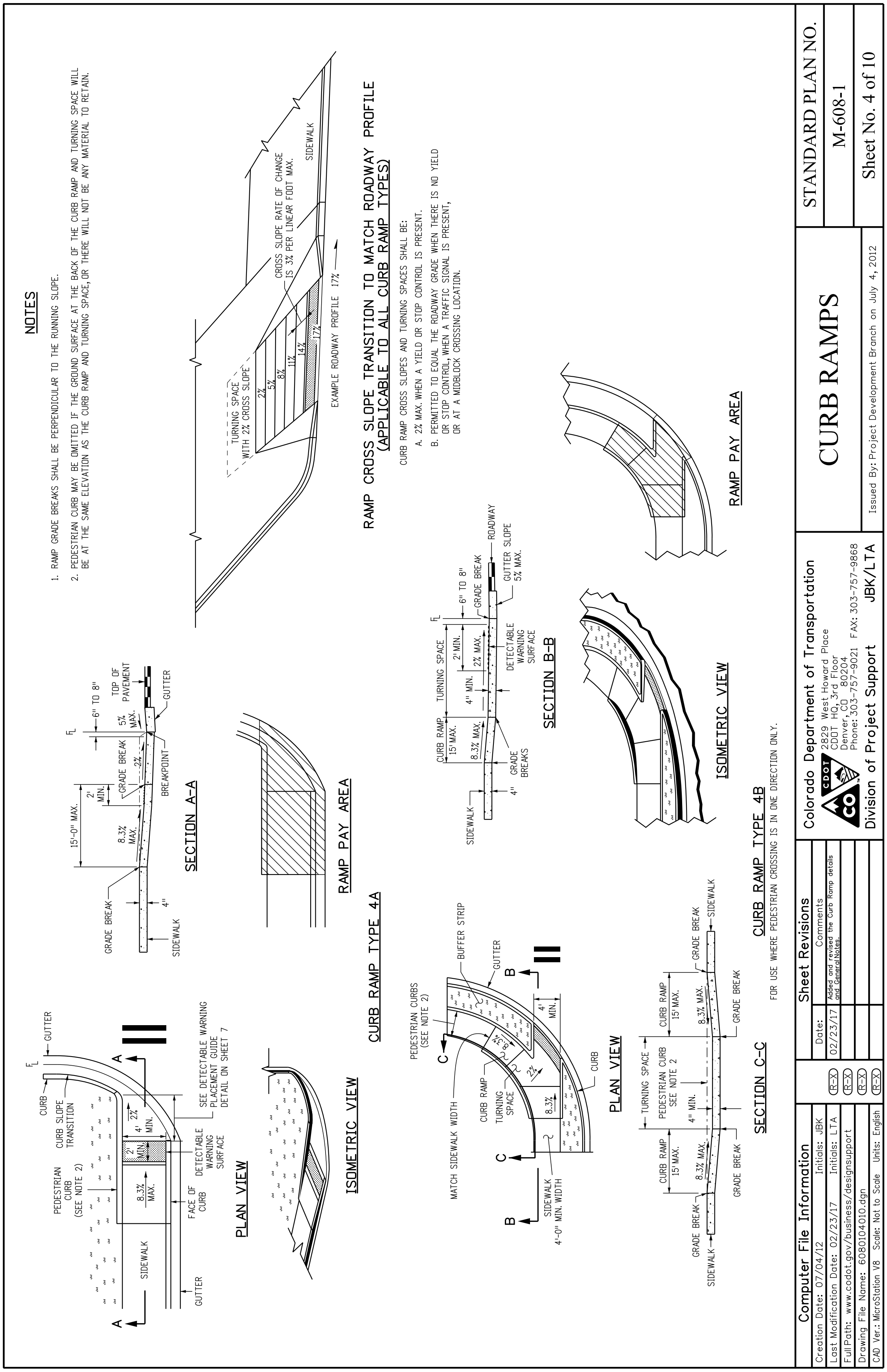


Figure 1.20 - Typical Curb Ramps
Original Detail CDOT Standard Plan No. M-608-1; 4 of 10

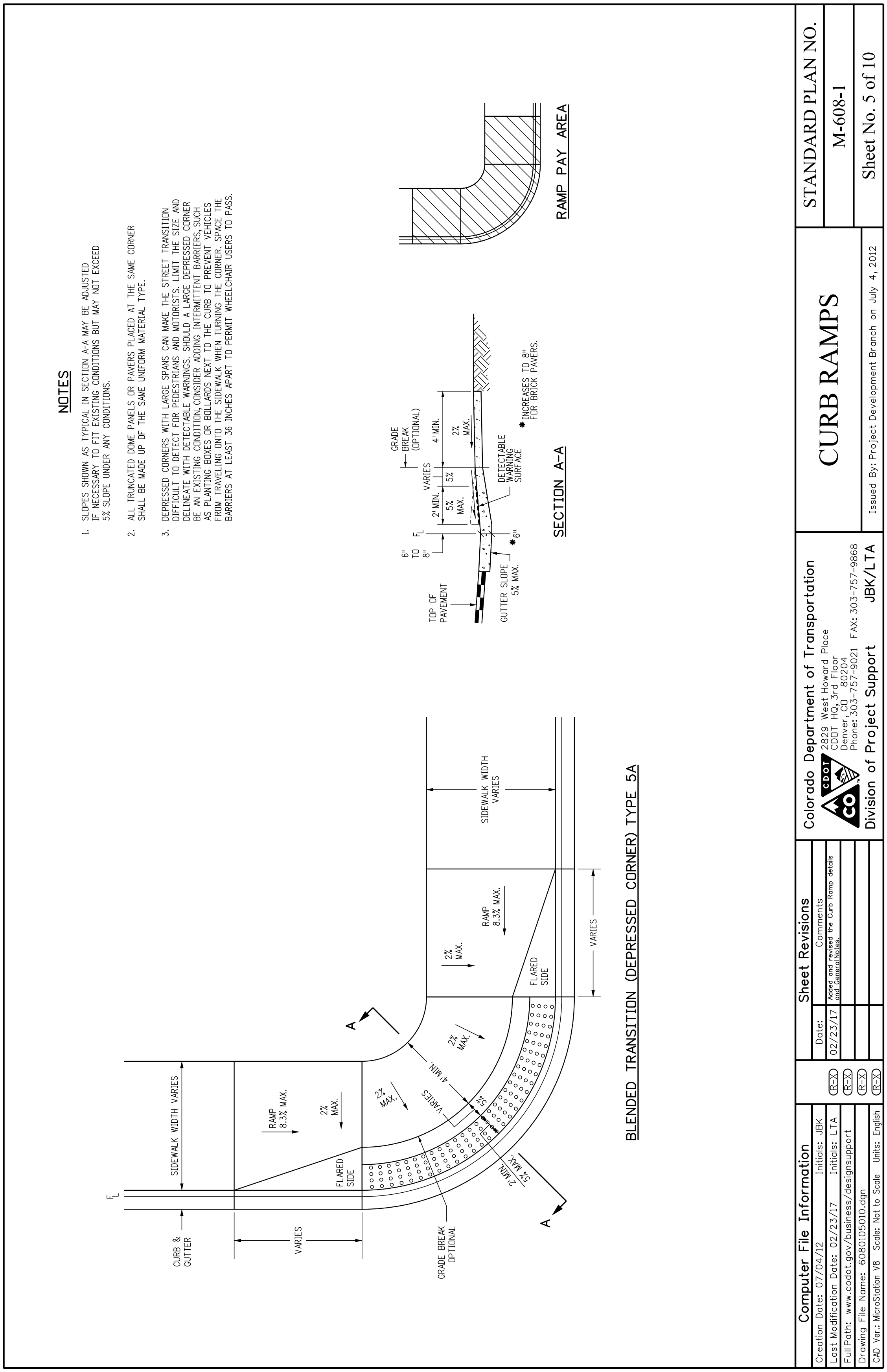


Figure 1.21 - Typical Curb Ramps
Original Detail CDOT Standard Plan No. M-608-1; 5 of 10

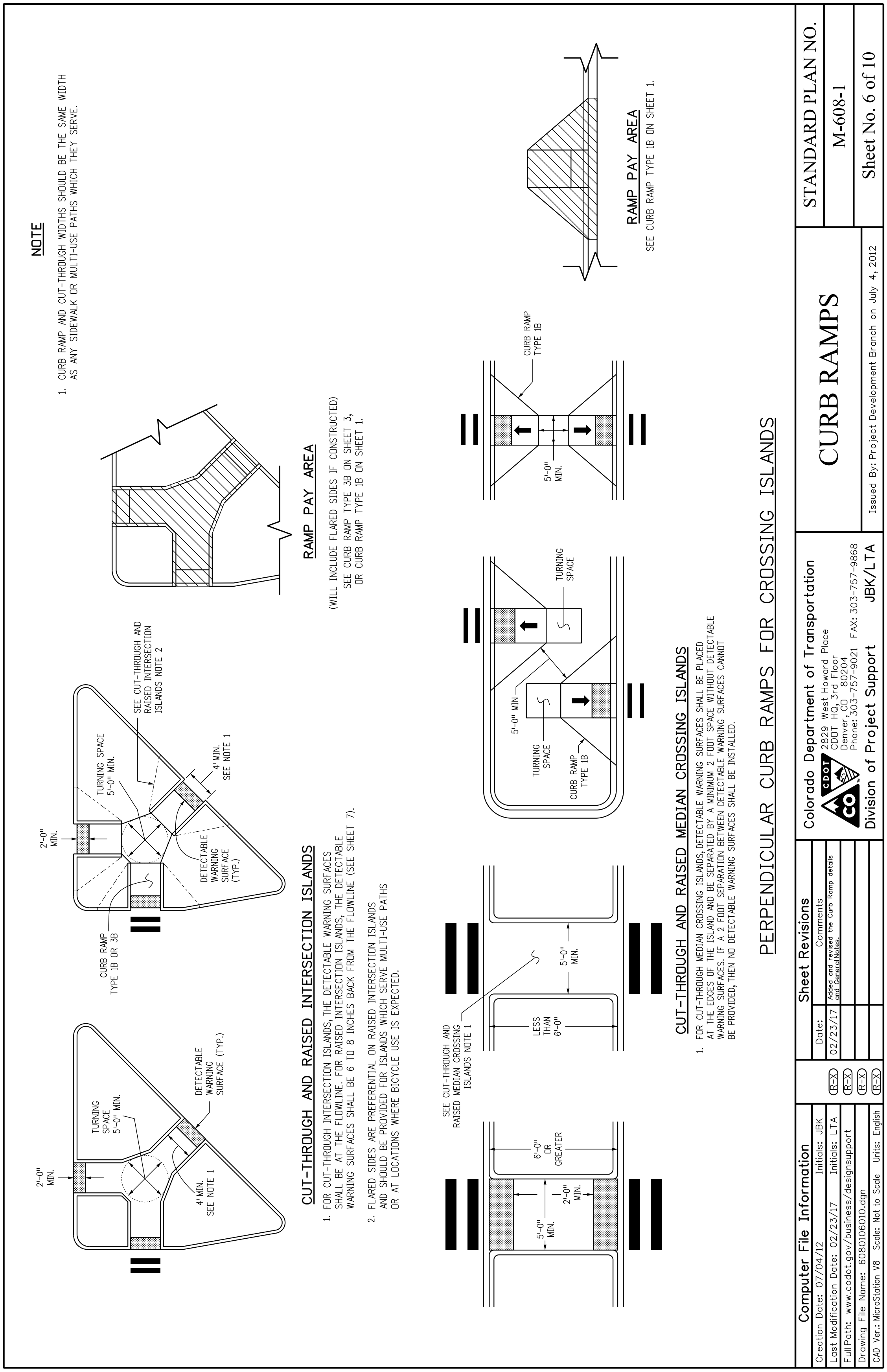


Figure 1.22 - Typical Curb Ramps
Original Detail CDOT Standard Plan No. M-608-1; 6 of 10

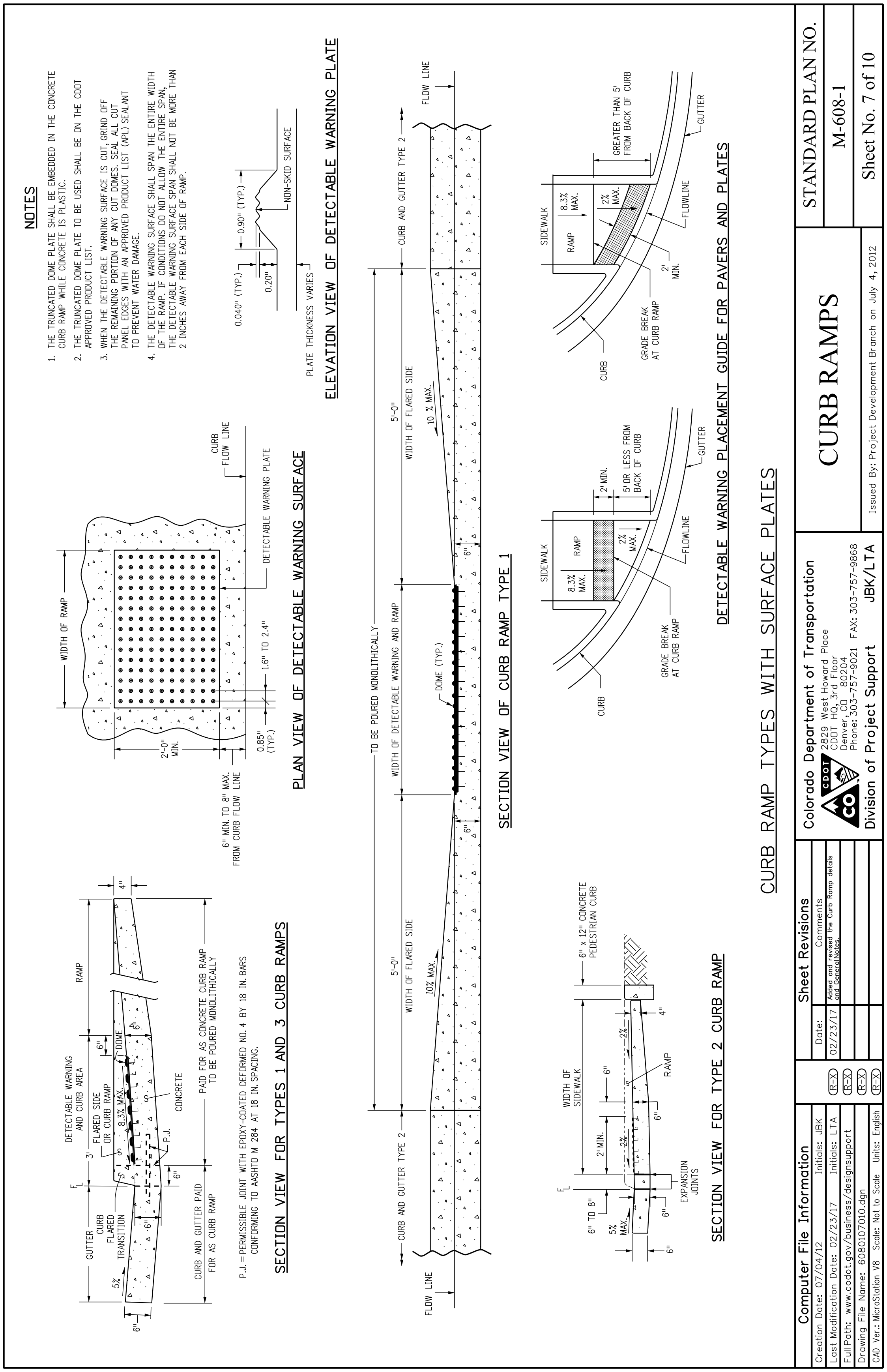


Figure 1.23 - Typical Curb Ramps
Original Detail CDOT Standard Plan No. M-608-1; 7 of 10

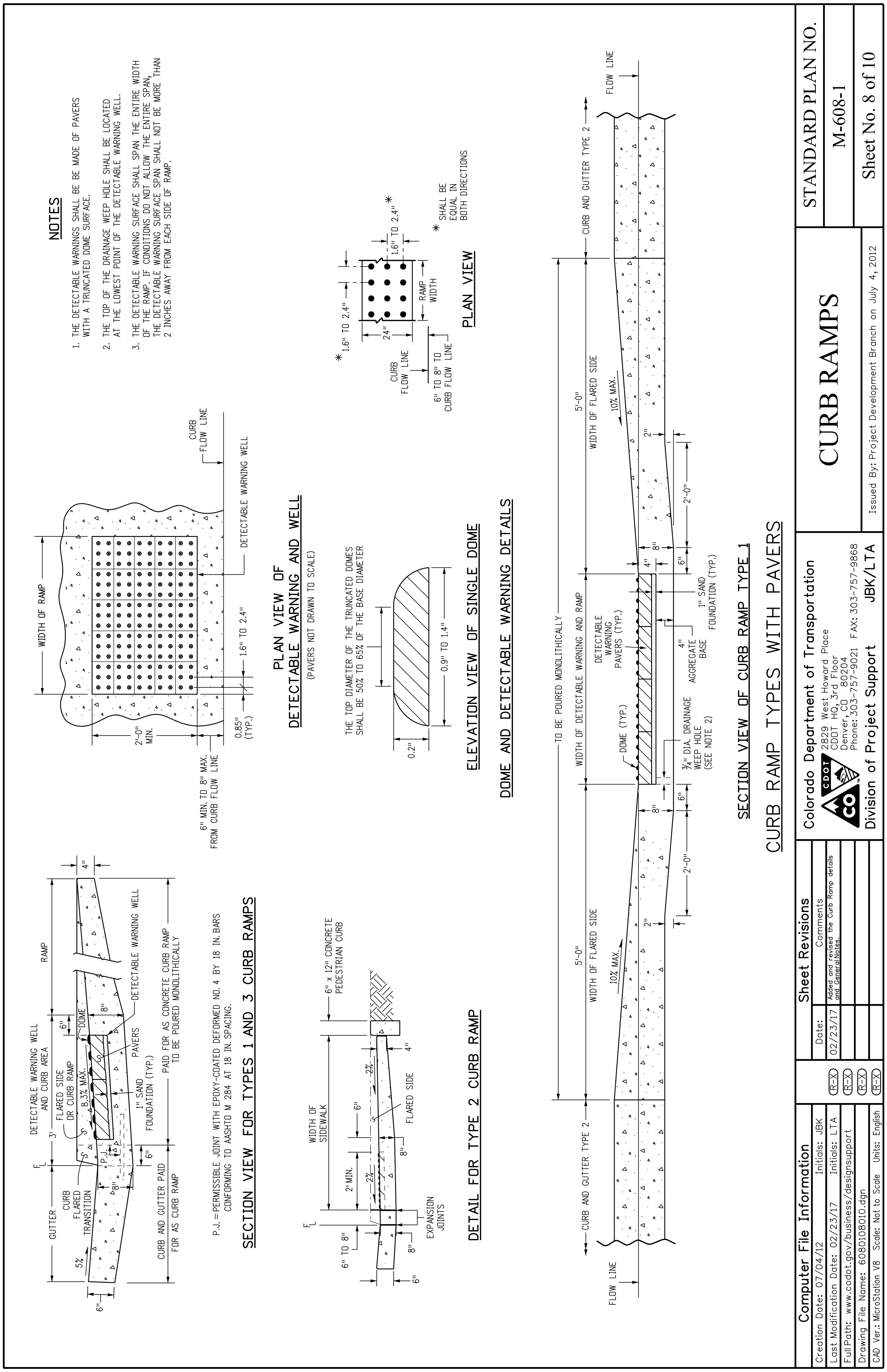


Figure 1.24 - Typical Curb Ramps
Original Detail CDOT Standard Plan No. M-608-1; 8 of 10

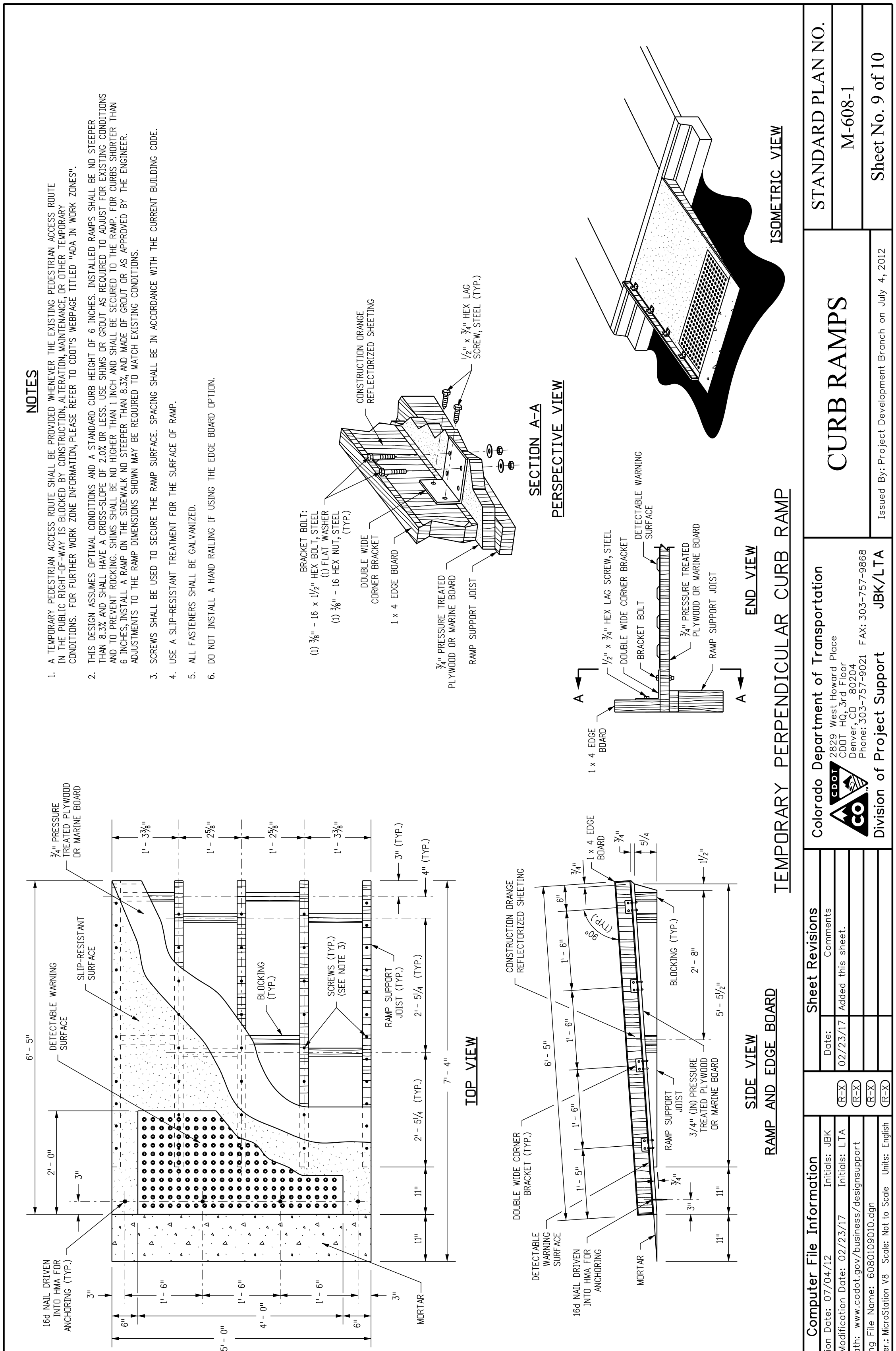


Figure 1.25 - Typical Curb Ramps
Original Detail CDOT Standard Plan No. M-608-1; 9 of 10

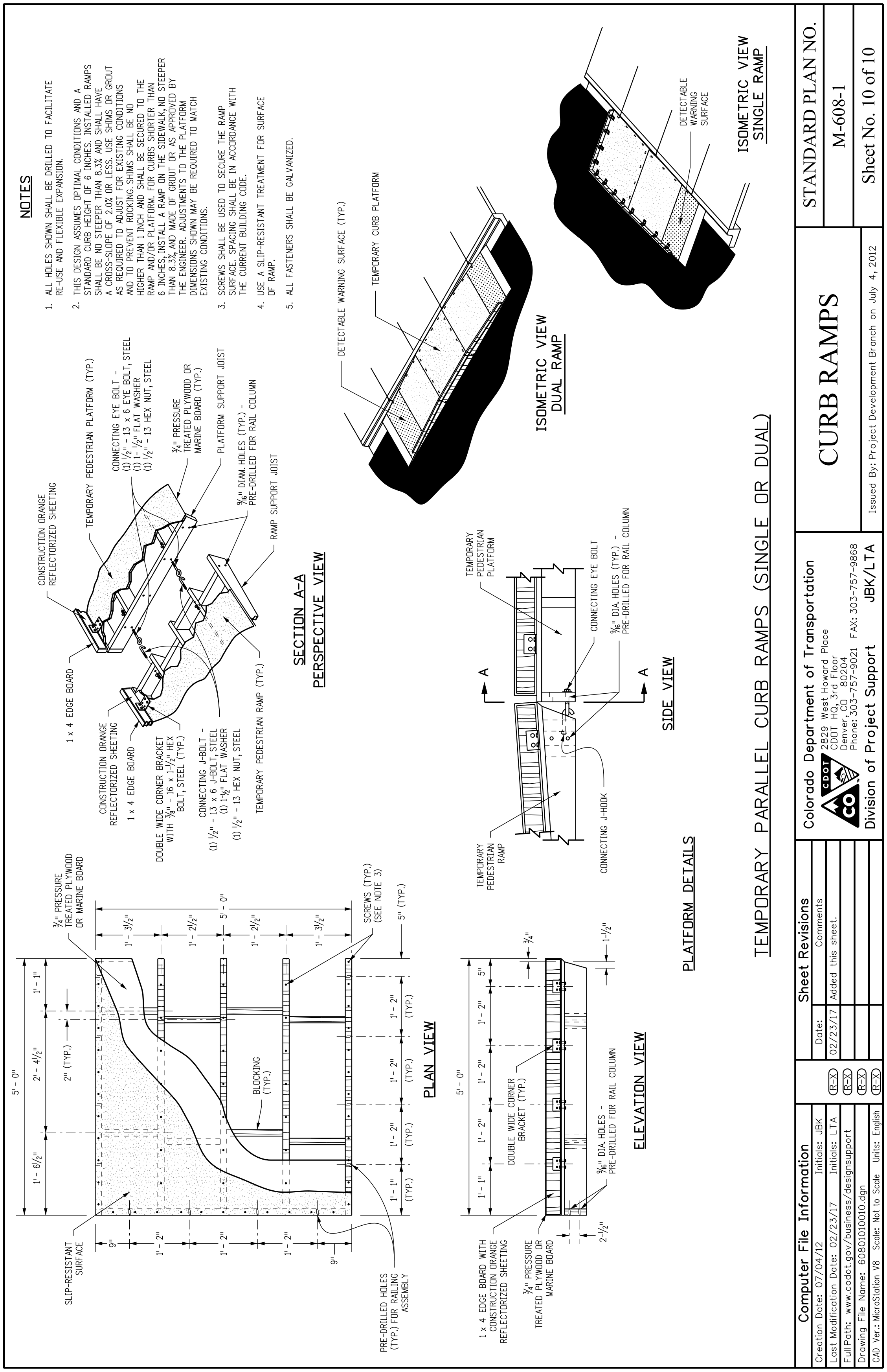


Figure 1.26 - Typical Curb Ramps
Original Detail CDOT Standard Plan No. M-608-1; 10 of 10

1.7 Drainage Swales and Irrigation Ditches

For the purposes of this manual, the term 'ditch' refers to a raw irrigation water conveyance and 'swale' refers to a stormwater conveyance. Provide a minimum of 5' horizontal separation from the nearest edge of pavement of the trail surface to the top of bank of the ditch or swale. Where the top of bank of the ditch or swale is lower than the edge of trail grade, provide a minimum of 2.5' horizontal separation per each 1' of vertical grade change.

The typical condition for a raw water conveyance ditch is 18" depth by 24" width channel with vertical sides and compacted native soil or, preferably, a blended clay soil liner. The dimensions will vary with the actual ditch volume; generally a depth of 2/3 to 3/4 the width of the ditch, scaled to provide the actual flow capacity, is appropriate. Ditch water owners may have access rights and maintenance responsibilities within or immediately adjacent to the Rio Grande corridor.

The typical condition for stormwater swale is a vegetated channel with side slopes of 3:1 preferred (2:1 maximum). Channel bottom may be reinforced with 6-12" riprap if flows or slope indicate erosion is likely. Unless necessary for structure/infrastructure protection, stormwater conveyance ditches should not be lined, and should target a running slope of less than 3% to encourage infiltration and sediment removal. Vegetated stormwater ditches require occasional cleaning, overgrowth removal, and active weed management; and may also require erosion control blanket and/or wattle check dams during initial revegetation.

Maintain or reconnect all existing swale and ditch routes and confirm by calculation the capacity of existing and proposed swale, ditch, or pipe infrastructure in the design of new improvements in the corridor. New piped infrastructure is to be a minimum of 18" diameter and may be constructed of corrugated metal pipe (CMP), reinforced concrete pipe (RCP), corrugated plastic pipe (CPP), or high-density polyethylene (HDPE). Typical minimum cover for drainage infrastructure is to be 8" or greater as dictated by the selected material and expected loading requirements. All pipe daylights are to be a minimum of 3' from edge of trail or other pavements and shall be fitted with flared end sections (FES).

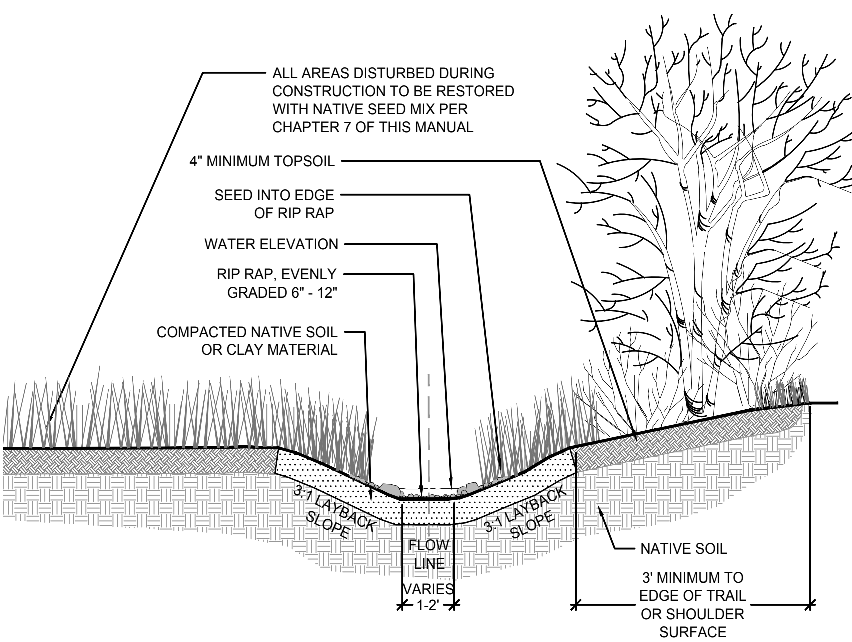


Figure 1.27 - Typical Drainage Swale
Original detail by DHM Design

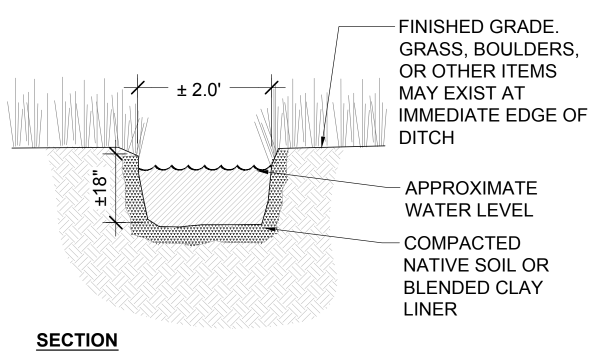
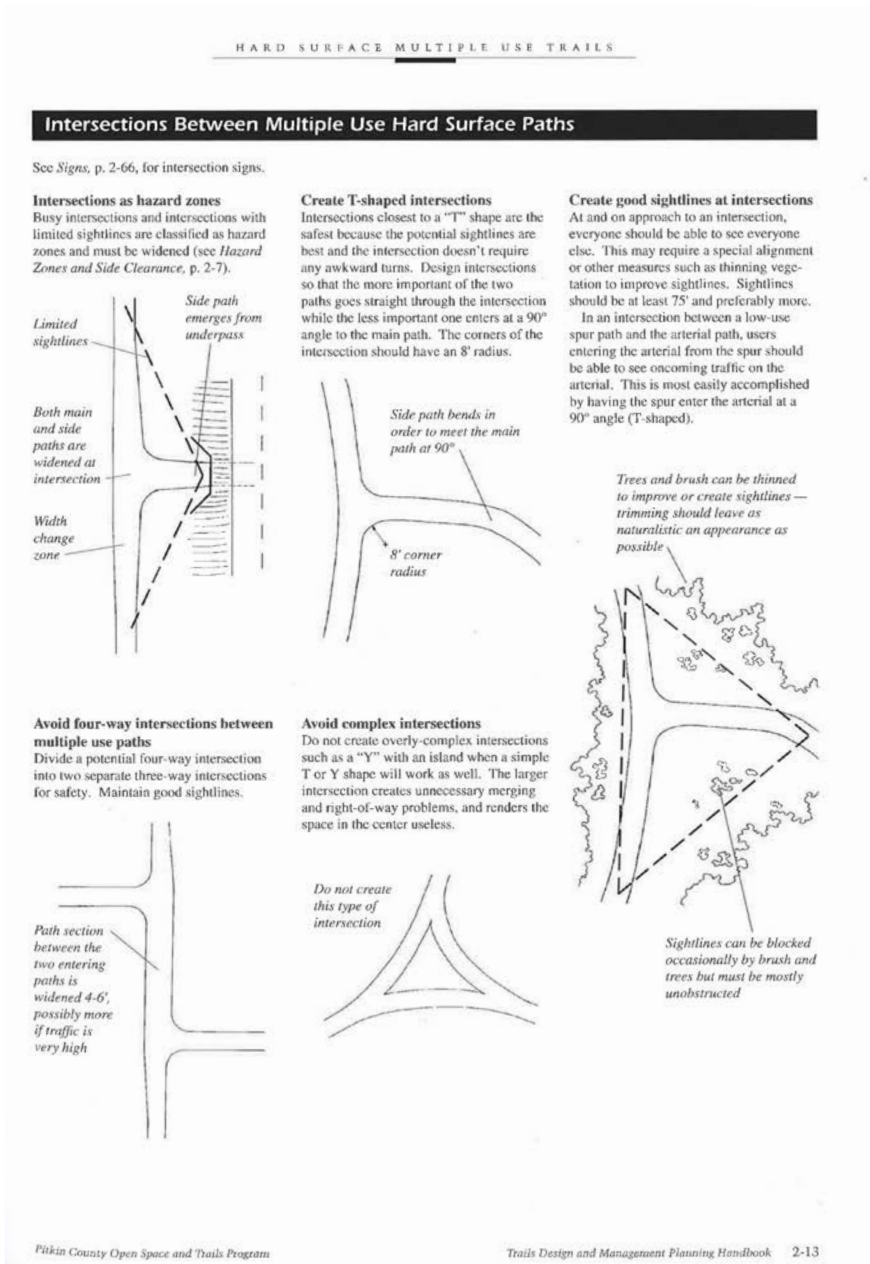


Figure 1.28 - Typical Ditch
Original detail by DHM Design

2 Intersections and Approaches

2.1 Paved Trail Intersection

Considerations for the layout of paved trail intersections with the Rio Grande Trail: Paved trail intersections shall be designed with a focus on safe cross-traffic interactions, appropriate sight lines, clear trail hierarchy and intuitive direction-finding. The following information, excerpted from Pitkin County OST's Trails Design and management Handbook, illustrates guidelines for laying out a paved trail intersection.


HARD SURFACE MULTIPLE USE TRAILS

Intersections Between Multiple Use Hard Surface Paths

See *Signs,* p. 2-66, for intersection signs.

Intersections as hazard zones
Busy intersections and intersections with limited sightlines are classified as hazard zones and must be widened (see *Hazard Zones and Side Clearance,* p. 2-7).

Create T-shaped intersections
Intersections closest to a "T" shape are the safest because the potential sightlines are best and the intersection doesn't require any awkward turns. Design intersections so that the more important of the two paths goes straight through the intersection while the less important one enters at a 90° angle to the main path. The corners of the intersection should have an 8' radius.

Create good sightlines at intersections
At and on approach to an intersection, everyone should be able to see everyone else. This may require a special alignment or other measures such as thinning vegetation to improve sightlines. Sightlines should be at least 75' and preferably more.
In an intersection between a low-use spur path and the arterial path, users entering the arterial from the spur should be able to see oncoming traffic on the arterial. This is most easily accomplished by having the spur enter the arterial at a 90° angle (T-shaped).

Avoid four-way intersections between multiple use paths
Divide a potential four-way intersection into two separate three-way intersections for safety. Maintain good sightlines.

Avoid complex intersections
Do not create overly-complex intersections such as a "Y" with an island when a simple T or Y shape will work as well. The larger intersection creates unnecessary merging and right-of-way problems, and renders the space in the center useless.

Pitkin County Open Space and Trails Program   Trails Design and Management Planning Handbook 2-13

Figure 2.1 - Hard surface multiple use trail intersection
Excerpted from Trails Design and Management Handbook Revision 1.1, Pitkin County Open Space and Trails Program. Original content by Troy Scott Parker, Natureshape

2.2 Grade Crossing

HARD SURFACE MULTIPLE USE TRAILS

Grade Crossings

The transfer point serves two functions here. First, it serves as the terminus for the crossing. Second, it serves as a transfer point from the road to the trail. The design of the trailhead areas on each side needs to reflect both functions, i.e., unify the sides and make the trailheads attractive and inviting gateways.

- A sign indicating the name of the trail should be visible to road users on each side of the road. Two signs will be needed — they should be identical in design and symmetric in placement so that together they help unify the two ends of the crossing for both motorists and path users.
- The trailhead area on each side should be treated as its own trailhead, but balanced as a whole with the other side. The balance should be a sophisticated asymmetric balance of colors, forms, and masses — not a mirror image or an exact balance of element to element. The whole of each side balances with the whole of the other side, but individual elements on each side don't necessarily balance their counterparts by themselves. Each side should appear equally important, equally attractive, and equally inviting.

Grade Crossings

This grade crossing is highly visible from the road and cohesive for trail users because the two sides are well anchored, asymmetrically balanced, and carefully matched in materials.

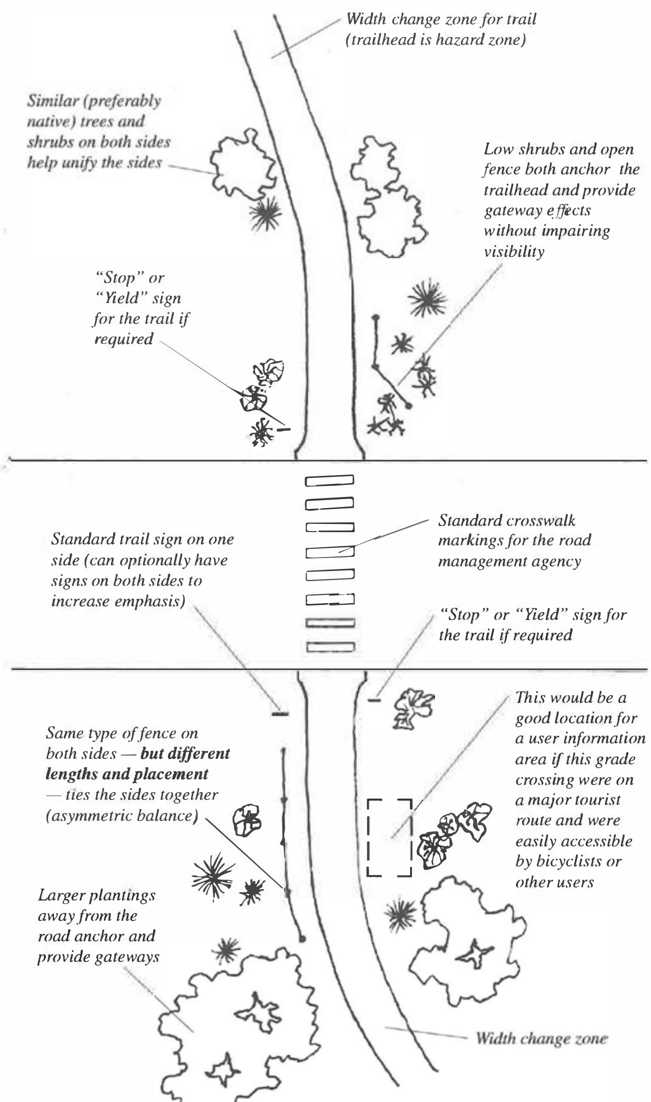


Figure 2.2 - Hard Surface Multiple Use Trails Grade Crossing
Excerpted from Trails Design and Management Handbook Revision 1.1, Pitkin County Open Space and Trails Program. Original content by Troy Scott Parker, Natureshape

2.3 Roads: Driveways, Minor Roads, Major Roads, Signalized Intersections

Criteria for Crossing Treatments at Uncontrolled Locations

Roadway Configuration	# of lanes crossed to reach a refuge[1]	# of multiple threat lanes[2] per crossing	Roadway ADT and Posted Speed															
			500-5,000 vpd				5,000-9,000 vpd				9,000-12,000 vpd				> 12,000 vpd			
			≤ 30 mph	35 mph	40 mph	≥ 45 mph	≤ 30 mph	35 mph	40 mph	≥ 45 mph	≤ 30 mph	35 mph	40 mph	≥ 45 mph	≤ 30 mph	35 mph	40 mph	≥ 45 mph
Single-family Driveway			*No treatment required.*															
Other Driveways / Roadways < 500 vpd			*Install marked crosswalk.*															
2 Lanes (one way street)	2	1	A	B	C	F	A	B	C	F	B	B	C	F	B	C	C	F
2 Lanes (two way street with no median)	2	0	A	B	C	F	A	B	C	F	B	B	C	F	B	C	C	F
3 Lanes w/Raised Median	1 or 2	0 or 1	A	B	E	F	D	C	E	F	B	E	E	F	C	E	E	F
3 Lanes w//Striped Median	3	0 or 1	D	C	E	F	D	C	E	F	C	C	E	F	C	E	E	F
4 Lanes (two way street with no median)	4	2	A	E	E	F	C	E	E	F	B	E	E	F	E	E	E	F
5 Lanes w/Raised Median	2 or 3	2	A	B	E	F	C	C	E	F	B	C	E	F	C	C	E	F
5 Lanes w/Striped Median	5	2	E	E	E	F	E	E	E	F	E	E	E	F	E	E	E	F

Notes:

1. Painted medians can never be considered a refuge for a crossing pedestrian. Similarly, a 4 foot wide raised median next to a left turn lane can only be considered a refuge for pedestrians if the left turning volume is less than 20 vehicles per hour (meaning that in most cases the left turn lane is not occupied while the pedestrian is crossing).
2. A multiple threat lane is defined as a through lane where it is possible for a pedestrian to step out from in front of a stopped vehicle in the adjacent travel lane (either through or turn lane).

Treatment Descriptions:

A ***Install marked crosswalk with enhanced road-side signs***

Specific Guidance : Install marked crosswalk with "State Law - Yield to Pedestrian" signs mounted on the side of the roadway with standard (W11-15) advance pedestrian warning signs; use S1-1 signs for School Crossing locations.

B ***Install marked crosswalk with enhanced road-side and flexible in-roadway signs***

Specific Guidance : Install marked crosswalk with "State Law - Yield to Pedestrian" signs mounted on the side of the roadway and on flexible in-roadway posts; use standard (W11-15) advance pedestrian warning signs; use S1-1 signs for School Crossing locations.

C ***Install marked crosswalk with enhanced signs and geometric improvements to increase pedestrian visibility and reduce exposure***

Specific Guidance : For 2 or 3-lane roadways, install marked crosswalk with "State Law - Yield to Pedestrian" signs mounted on the side of the roadway and on in-roadway bollards or median mounted signs; use standard (W11-15) advance pedestrian warning signs; use S1-1 signs for School Crossing locations. Add neckdowns or median refuge islands to shorten the pedestrian crossing distance and increase pedestrian visibility to motorists.

D ***Install raised crosswalk with enhanced signs and geometric improvements to increase pedestrian visibility and reduce exposure***

Specific Guidance : Install 3"-4" tall raised crosswalk with "State Law - Yield to Pedestrian" signs mounted on the side of the roadway and on in-roadway bollards or median mounted signs; use standard (W11-15) advance pedestrian warning signs; use S1-1 signs for School Crossing locations. Add neckdowns or median refuge islands to shorten the pedestrian crossing distance and increase pedestrian visibility to motorists. The raised crosswalk shall be colored or striped to alert driver of the raised grade.

E ***Install marked crosswalk with enhanced signs, pedestrian activated Rectangular Rapid Flash Beacons (RRFBs), and geometric improvements to increase pedestrian visibility and reduce exposure***

Specific Guidance: Install raised median refuge island (unless it is a one-way street or one already exists) to shorten the pedestrian crossing distance and increase pedestrian visibility to motorists. Install marked crosswalk with "State Law - Yield to Pedestrian" signs WITH pedestrian activated RRFBs mounted on the side of the roadway and on median mounted signs (Tapco RRFB-XL, or RFTA approved equal); use standard (W11-15) advance pedestrian warning signs; use S1-1 signs for School Crossing locations. Consider adding neckdowns at the crossing if on-street parking exists on the roadway and storm drain considerations will allow.

F ***Do not install marked crosswalk at uncontrolled crossing. Determine if the speed limit can be effectively reduced to 40 mph AND a raised refuge median can be installed. If so, utilize Scenario E criteria above. If this is not possible, or if pedestrian volume falls above the RRFB limit line on Figure 2, consider High intensity activated crosswalk (HAWK) beacon, pedestrian traffic signal, or grade-separated crossing.***

Specific Guidance : Consider HAWK beacon, pedestrian traffic signal or grade-separated crossing; application of these treatments will consider corridor signal progression, existing grades, physical constraints, and other engineering factors

Figure 2.3 - Criteria for Crossing Treatments at Uncontrolled Locations
Excerpted from City of Boulder Pedestrian Crossing Treatment Installation Guidelines. Provided by SEH, original content by City of Boulder.

Note: There are many alternative designs for trail crossings of roadways. The City of Boulder, Colorado Pedestrian Crossing Treatment Installation Guidelines 2011 present good guidance for selecting the appropriate crossing based on roadway traffic volume and roadway speed limit. Each specific application should be coordinated with the jurisdiction having ownership of the roadway.

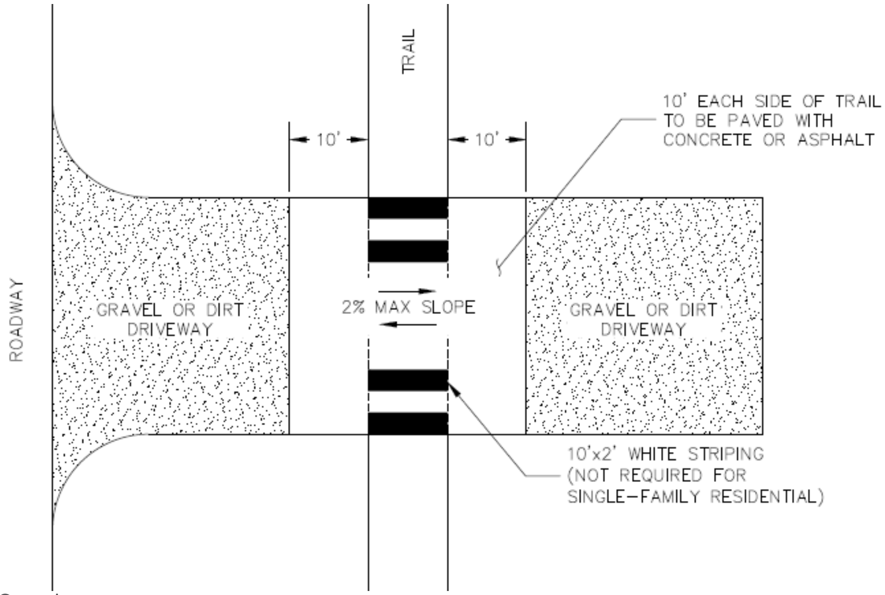
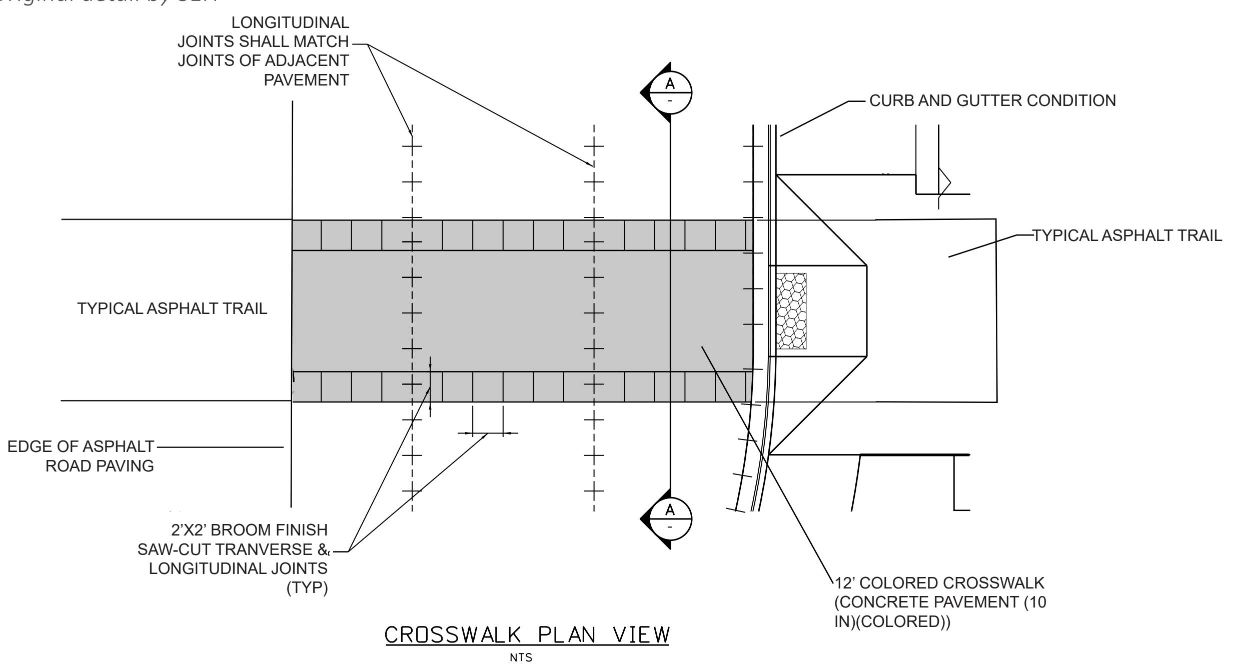


Figure 2.4 - Gravel or Unpaved Driveway/Road Crossing
Original detail by SEH



Note:
The typical condition for a crosswalk in the corridor is striped. Individual conditions may warrant a color concrete installation. Individual applications are to be designed per specific conditions and conforming to this standards document.

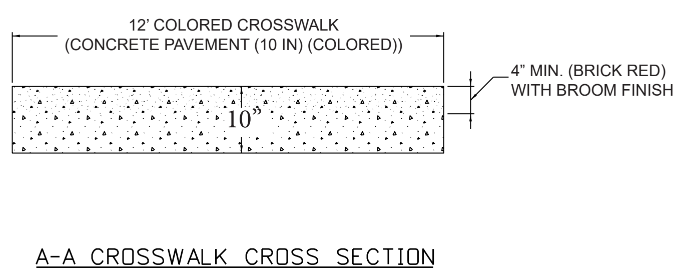


Figure 2.5 - Crosswalk Plan, Detail and Cross Section
Detail provided by RFTA. Original detail by Baker

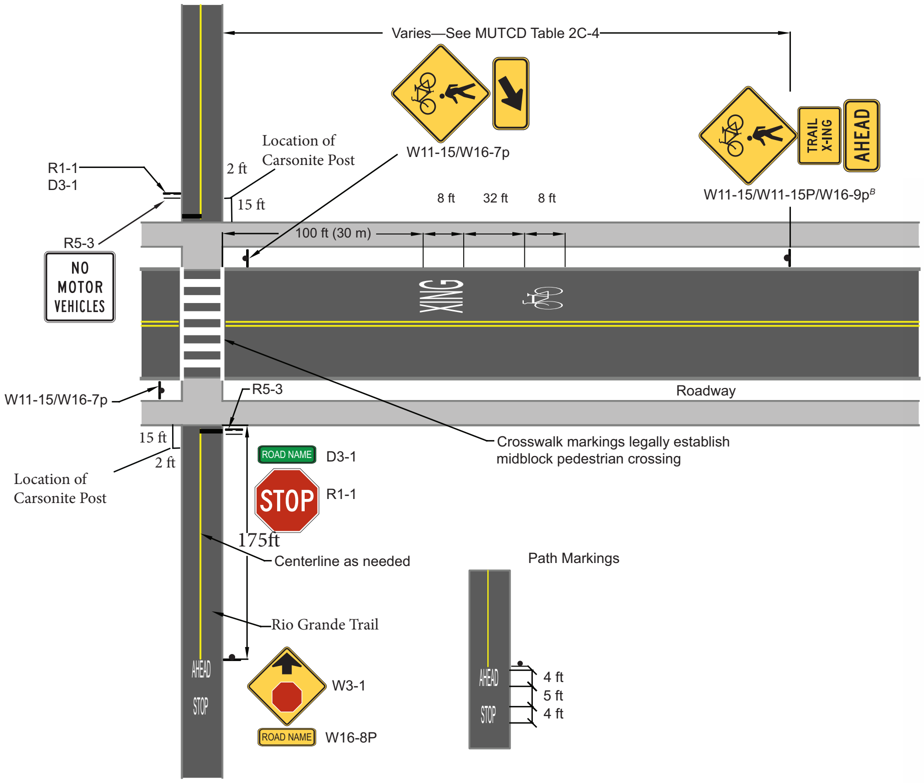


Figure 2.6 - Paved Trail Mid-Block Road Crossing
Original detail from MUTCD.

Note: Path is stop-controlled for trail users.

Carsonite Post with “Open To” and “Closed To” instructions.

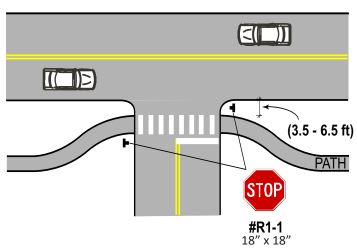


Figure 5-23 (B)

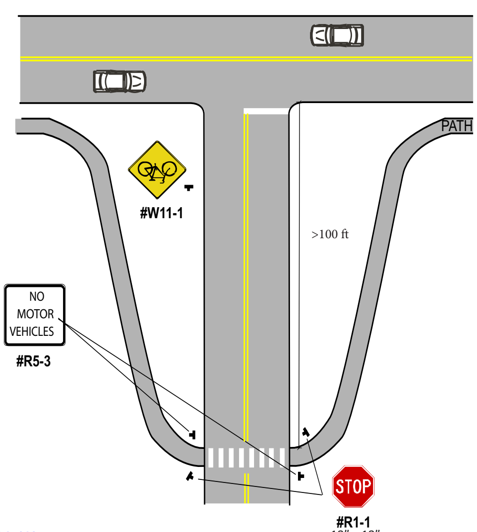


Figure 5-23 (C)

Notes:
1)Trail approaches are to be signed/striped similar to midblock crossing.

2) Trail crossings at signalized intersections should approach at the corner; crossings should be designed to comply with local jurisdiction requirements and this standards document.

3) Include three rail fence barrier for parallel sections within 30’ of roadway edge.

Figure 2.7 - Paved Trail Crossing at Road Intersection- Signalized or Stop Controlled
Original detail from MUTCD.

3 Earthwork

This chapter is intended to provide general guidance for the approach to integrating a trail section and trail amenities into a variety of topographic conditions. Specific site conditions, soil types, drainage needs, and context will require individual geotechnical and civil design.

3.1 Trail Excavation and Embankment

Note: for the purposes of this Section 3.1, 'topsoil' shall be classified per 2017 CDOT Standard Specifications Book section 207.02: "Topsoil shall consist of loose friable soil from the zone of major root development free of subsoil, refuse, stumps, woody roots, rocks, brush, noxious weed seed and reproductive plant parts from current state and county weed lists, heavy clay, hard clods, toxic substances, or other material which would be detrimental to its use on the project."
'Embankment' and 'fill' shall be construed to mean 'Soil Embankment' per section 203.03 of the 2017 CDOT Standard Specifications Book: "Soil Embankment shall have all particle sizes less than 6 inches. The material shall be classified in accordance with AASHTO M 145 and placed and compacted in accordance with subsection 203.07(a)." Section 203.07(a) states:

203.07

203.07 Embankment Placement and Compaction Requirements. Materials incorporated into embankment fill shall be placed and compacted according to the following requirements:

(a) *Soil Embankment*. All soil embankment shall be placed in horizontal layers not to exceed 8 inches in loose lift thickness. Each layer shall be compacted prior to the placement of subsequent layers. Spreading equipment shall be used to obtain uniform thickness prior to compaction. As the compaction progresses, continuous mixing, leveling, and manipulating shall be done to assure uniform moisture and density. Additional work involved in drying soil embankment to the required moisture content shall be included in the contract price paid for excavating or furnishing the material with no additional compensation.

Soil embankment that is classified as A-1 material may be used to bridge across standing water or swampy ground within the embankment foundation, and may be placed in lift thicknesses greater than 8 inches when used for this purpose if approved by the Engineer.

Soil embankment with less than or equal to 30 percent retained on the ¾-inch sieve shall be tested for compaction using CP 80. Materials classified as AASHTO A-1, A-2-4, A-2-5, and A-3 soils shall be compacted at ± 2 percent of Optimum Moisture Content (OMC) and to at least 95 percent of maximum dry density determined in accordance with AASHTO T 180 as modified by CP 23. All other soil types shall be compacted to 95 percent of the maximum dry density determined in accordance with AASHTO T 99 as modified by CP 23. Soils with 35 percent fines or less shall be compacted at ± 2 percent of OMC. Soils with greater than 35 percent fines shall be compacted at a moisture content equal to or above OMC to achieve stability of the compacted lift. Stability is defined as the absence of rutting or pumping as observed and documented by the Contractor's Process Control Representative and as approved by the Engineer. If the soils cannot be compacted and prove to be unstable at a moisture content equal to or above OMC, then the required moisture content for compaction may be reduced below OMC if approved by the Engineer.

(Continued next page)

Prior to placing any soil embankment with greater than 30 percent retained on the ¾-inch sieve, the Contractor shall construct a test strip to the dimensions specified in the Contract or as directed by the Engineer. The test strip may be incorporated into the final embankment. The Contractor shall determine the moisture conditioning necessary to achieve compaction, and shall determine the equipment and number of passes necessary to achieve adequate compaction. The Contractor shall use compression-type or vibratory rollers on granular materials and sheepsfoot rollers on cohesive soils. Adequate compaction shall be demonstrated by the absence of rutting, pumping, or deflection following a proof roll of the test strip using any piece of construction equipment that exerts a minimum 18-kip per axle load. The proof roll will be observed and accepted by the Engineer. Once the test strip passes a proof roll, the Contractor may resume embankment construction using the same moisture conditioning and compaction methods that were used to construct the test strip.

Placement, moisture conditioning, and compaction of every lift of soil embankment with greater than 30 percent retained on the ¾-inch sieve shall be observed by the Contractor's Process Control Representative, and accepted by the Engineer. Adequate compaction of each lift shall be demonstrated as the absence of rutting, pumping, or deflection as construction equipment is routed over a lift following the compactive efforts that were used and accepted for the respective test strip. The Engineer may request a proof roll at any time to document the condition of a lift.

Significant changes in the material being hauled for soil embankment with greater than 30 percent retained on the ¾-inch sieve will require construction of a new test strip, and demonstration of adequate compaction methods using a proof roll.

Non-durable bedrock shall be watered to promote slaking and break down, and pulverized or processed to a maximum particle size of 6 inches. These materials shall be placed and compacted as soil embankment, except they shall be compacted with a heavy tamping foot roller weighing at least 30 tons. Each tamping foot shall protrude from the drum a minimum of 4 inches. Each embankment layer shall receive a minimum of four passes with the tamping foot roller. The roller shall be operated at a uniform speed not exceeding 3 miles per hour. No additional compensation will be made for additional roller passes to achieve specified density requirements.

Non-durable Bedrock shall not be used to bridge over standing water or swampy ground within an embankment foundation. Non-durable bedrock shall also not be placed within 2 feet of the final subgrade elevation.

Figure 3.1 - Embankment Placement and Compaction Requirements, pages 196-197
Excerpted from 2017 CDOT Standard Specifications Book

The information provided below is excerpted from the Trails Design and Management Handbook, Pitkin County Open Space and Trails. The original content of the excerpted material was developed by Natureshape (www.natureshape.com).

Cut/Fill Construction

Cut and fill construction can be used on cross slopes up to 30% in areas where all three following conditions are met:

- Soils are stable enough to use as fill
- The prospects of revegetation are good
- Vegetation disturbed by the cut and fill is easily replaced

Cut and fill sections can be alternated with full bench sections where trailside vegetation needs to be preserved (see "Full Bench Construction," following).

Cut and fill slopes should mimic natural landforms along the trail and should vary whenever it makes sense to vary (appropriateness).

Where the soft surface trail is not adjacent to the hard surface, provide an 18" shoulder at the outside edge of the hard surface.

Where superelevation pitches the trail surface inward or moderate runoff is expected from above, provide a side swale on the inside

GRADING SPECIFICATIONS

Topsoil which covers areas to be cut or filled shall be removed and stockpiled for site restoration.

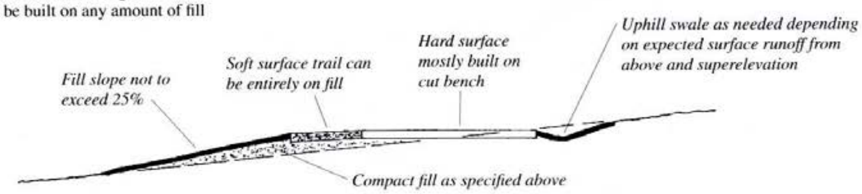
Suitable material removed from the excavations shall be used as far as practicable for embankments and backfilling. Unsuitable material shall be excavated below grade and replaced with select material suitable for the hard surface (see *Concrete Path Specifications*, p. 2-18, and *Asphalt Path Specifications*, p. 2-23). Excavated materials which are considered unsuitable and any surplus of excavated material not required for embankments or backfill shall be disposed of by the Contractor.

Fills and Embankments
Fills and embankments shall be constructed by depositing, placing and compacting materials of acceptable quality above the natural ground in accordance with the specifications below. Clearing, tree removal, and topsoil removal shall be performed before any embankment is placed.

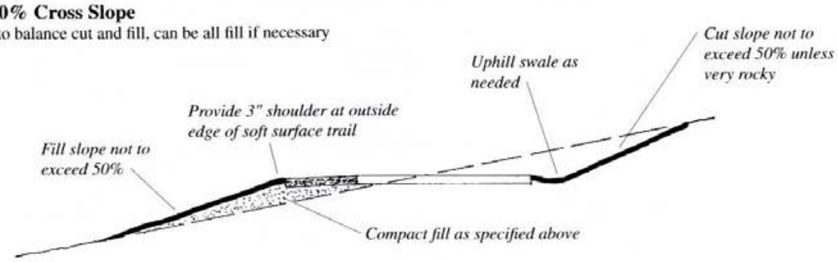
- Remove and dispose of obstructions and rubbish to a minimum depth of 12" below subgrade elevation
- Remove trees and stumps to a minimum depth of 8" below subgrade elevation
- Remove sod to a minimum depth of 6"

Each lift of embankment material not to exceed 6" of loose depth shall be thoroughly mixed and moistened to full depth and compacted to uniform minimum density of 90% of maximum density and optimum moisture content of plus or minus 2%.

■ 10% Cross Slope
Can be built on any amount of fill



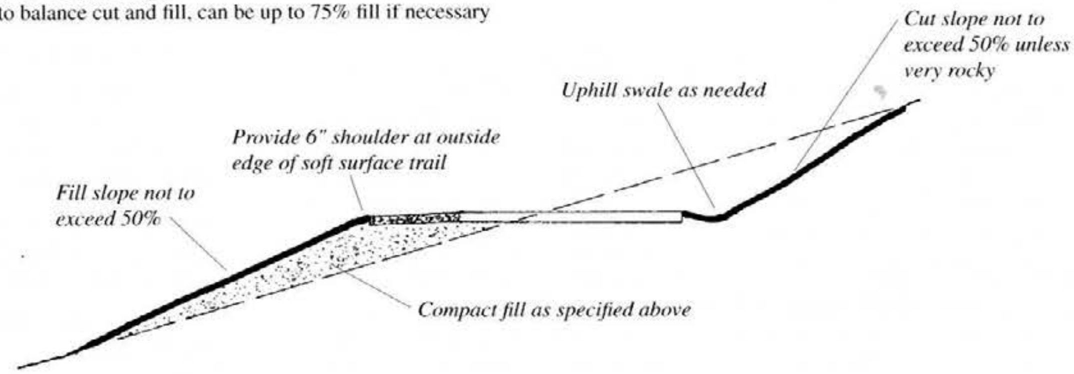
■ 20% Cross Slope
Try to balance cut and fill, can be all fill if necessary



Pitkin County Open Space and Trails Program — *Trails Design and Management Planning Handbook* 2-27

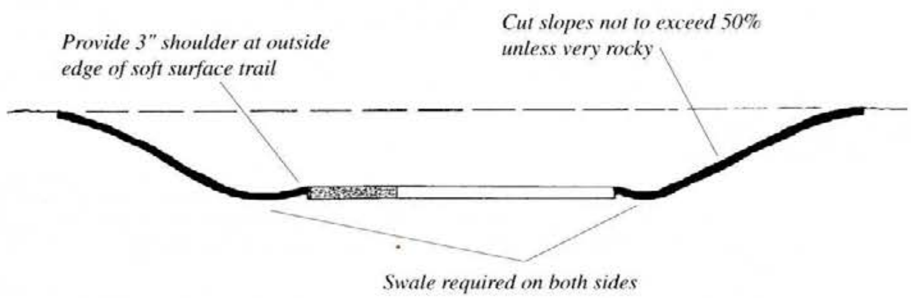
Figure 3.2 - General Trail Grading Standards and Typical Grading Sections, Page 2-27
Excerpted from Trail Design and Management Handbook Revision 1.1, Pitkin County Open Space and Trails Program. Original content by Troy Scott Parker, Natureshape

■ 30% Cross Slope
Try to balance cut and fill, can be up to 75% fill if necessary

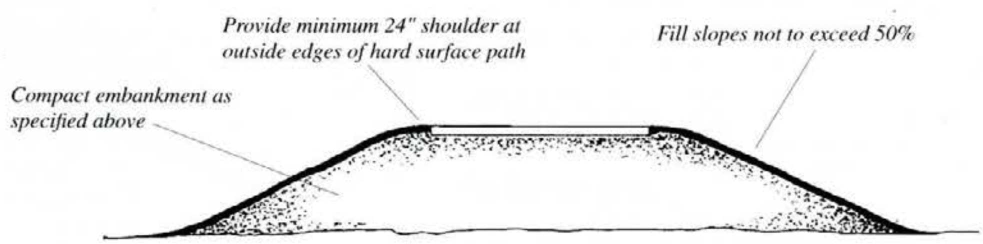


■ Greater than 30% Cross Slope
Use full bench construction (see "Full Bench Construction," following)

■ Full Cut
Soft surface trail is optional



■ Embankment
The adjacent soft surface trail, if any, can be located on the original ground



2-28 *Pitkin County Open Space and Trails Program* *Trails Design and Management Planning Handbook*

Figure 3.3 - Typical Grading Sections, Page 2-28
Excerpted from Trail Design and Management Handbook Revision 1.1, Pitkin County Open Space and Trails Program. Original content by Troy Scott Parker, Natureshape

Full Bench Construction

Full bench construction is to be used on any cross slope with one or more of the following conditions:

- Cross slope exceeds 30%
- Soils are not stable enough to use as fill
- The prospects of revegetation are poor
- Vegetation which would be disturbed by a cut and fill is difficult to replace (i.e., mature trees, fragile or unresilient vegetation)

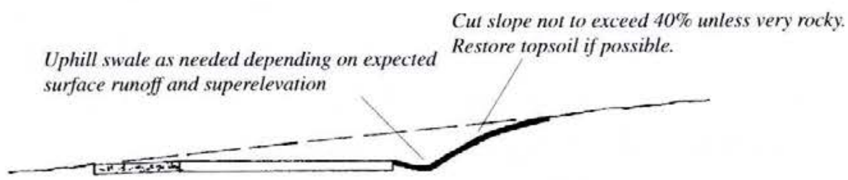
Full bench sections can be alternated with cut and fill sections where conditions permit (see previous page).

Remove and stockpile at least the top 6" of topsoil before excavating.

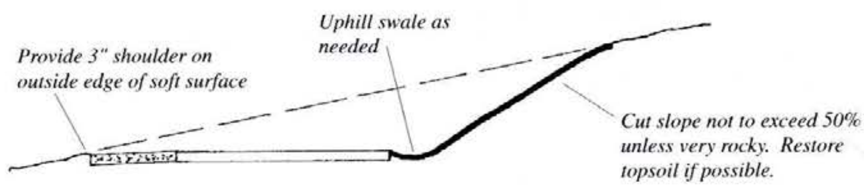
Where the soft surface trail is not adjacent to the hard surface, provide an 18" shoulder at the outside edge of the hard surface.

Where superelevation pitches the trail surface inward or moderate runoff is expected from above, provide a side swale on the inside edge. See *Superelevation*, p. 2-31, and *Path Drainage*, p. 2-32.

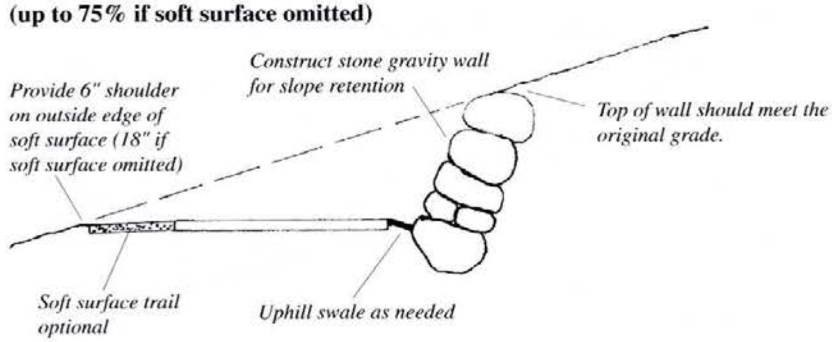
■ 10% Cross Slope



■ 20% Cross Slope



■ 30% to 60% Cross Slope
(up to 75% if soft surface omitted)



■ Greater than 60% Cross Slope
See next page

Pitkin County Open Space and Trails Program *Trails Design and Management Planning Handbook* 2-29

Figure 3.4 - Typical Grading Sections, Page 2-29
Excerpted from Trail Design and Management Handbook Revision 1.1, Pitkin County Open Space and Trails Program. Original content by Troy Scott Parker, Natureshape

3.2 Structure Excavation and Backfill

This standards document references the CDOT standard specification "Section 703 - Aggregates" and "Section 206 - Excavation and Backfill for Structures". These sections are provided below and provide performance expectations for materials associated with earthwork for structures. Individual projects will require specific geotechnical soils investigation, recommendations, and structural designs. Additionally, all federal, state, and local standards for shoring and safety apply.

703.08 **Structure Backfill Material.**

(a) Class I structure backfill shall meet the following gradation requirements:

Sieve Size	Mass Percent Passing Square Mesh Sieves
50 mm (2 inch)	100
4.75 mm (No. 4)	30-100
300 µm (No. 50)	10-60
75 µm (No. 200)	5-20

In addition this material shall have a liquid limit not exceeding 35 and a plasticity index of not over six when determined in conformity with AASHTO T 89 and T 90 respectively.

(b) Class 2 structure backfill shall be composed of suitable materials developed on the project. To be suitable for use under this classification, backfill shall be free of frozen lumps, wood, or other organic material. If the material contains rock fragments that, in the opinion of the Engineer, will be injurious to the structure, the native material shall not be used for backfilling and the Contractor shall furnish Class 1 structure backfill material at the contract unit price. If contract unit price does not exist for Class I structure backfill, it will be paid for in accordance with subsection 104.03.

Figure 3.5 - CDOT Section 206, Excavation and Backfill for Structures, Page 203
Original content by CDOT

206.02

Flow-Fill placed in areas that require future excavation, such as utility backfill shall have a Removability Modulus (RM) of 1.5 or less.

Removability Modulus, RM, is calculated as follows:

$$RM = \frac{W1.5 \text{ x } 104 \text{ x } C0.5}{106}$$

where : W = unit weight (pcf)
C = 28-day compressive strength (psi)

Materials for Structure Backfill (Flow-Fill) shall meet the requirements specified in the following subsections:

Fine Aggregate[1, 4]	703.01
Coarse Aggregate[2, 4]	703.02
Portland Cement	701.01
Fly Ash[3, 4]	701.02
Water	712.01
Air Entraining Admixture	711.02
Chemical Admixtures	711.03

[1] Fine aggregate not meeting the requirements of subsection 703.01 may be used if testing indicates acceptable results for strength and air content.

[2] Coarse aggregate not meeting the requirements of subsection 703.02 may be used if testing indicates acceptable results for strength and air content.

[3] Fly ash not meeting the requirements of subsection 701.02 may be used if testing indicates acceptable results for strength and air content.

[4] For industrial by-product aggregates (foundry sand, bottom ash, etc..) and fly ash not meeting the requirements of subsection 701.02 the Contractor shall submit a report from the supplier documenting the results of testing in accordance with the Toxicity Characteristic Leaching Procedure (TCLP) described in 40 CFR 261. The report shall include the results of TCLP testing for heavy metals and other contaminants. Materials shall not exceed the TCLP limits of 40 CFR 261.24 for heavy metals

Cellular foam shall conform to ASTM C869 and ASTM C796

Recycled broken glass (glass cullet) is acceptable as part or all of the aggregate. Aggregate including glass must conform to the required gradations. All containers used to produce the cullet shall be empty prior to processing. Chemical, pharmaceutical, insecticide, pesticide, or other glass containers containing or having contained toxic or hazardous

Figure 3.6 - CDOT Section 206, Excavation and Backfill for Structures, Page 204
Original content by CDOT

substances shall not be allowed and shall be grounds for rejecting the glass cullet. The maximum debris level in the cullet shall be 10 percent. Debris is defined as any deleterious material which impacts the performance of the Structure Backfill (Flow-Fill) including all non-glass constituents.

The Contractor may use aggregate which does not meet the above specifications if the aggregate conforms to the following gradation:

Sieve Size	Percent Passing
25.0 mm (1 inch)	100
75 µm (No. 200)	0-10[1]

[1]The amount of material passing the 75 µm (No. 200) screen may exceed 10 percent if testing indicates acceptable results for strength and air content.

The Contractor shall submit a Structure Backfill (Flow-Fill) mix design for approval prior to placement. The mix design shall include the following laboratory test data:

(1) ASTM C231, Air content.
(2) ASTM D6023, Unit Weight.
(3) ASTM C143, Slump or ASTM D6103 flow consistency.
(4) ASTM D4832 28-day Compressive Strength.
(5) Removability Modulus (RM).

3. Imported Structure Backfill for Pipes. Imported Material used as structure backfill for pipes (storm sewer, cross culverts, side drains, etc) shall be tested for compatibility with the selected pipe material.

When nonreinforced concrete pipe or reinforced concrete pipe is used, the imported material shall be tested for sulfate and pH.

When corrugated steel pipe, bituminous coated corrugated steel pipe or precoated corrugated steel pipe is used, the imported material shall be tested for sulfates, chlorides, pH and resistivity.

When aramid fiber bonded corrugated steel pipe or corrugated aluminum pipe is used, the imported material shall be tested for pH and resistivity.

When plastic pipe is selected, the imported material does not need to be tested for sulfates, chlorides, pH and resistivity.

Sulfates, chlorides, pH and resistivity shall be determined by the following procedures:

(1) Water soluble sulfates using CP-L 2103 Method B.

(2) Chlorides using CPL 2104.

Figure 3.7 - CDOT Section 206, Excavation and Backfill for Structures, Page 205
Original content by CDOT

206.02

(3) Resistivity using ASTM G57.

(4) pH using ASTM G51.

The average of three consecutive tests shall show the imported material's sulfate, chloride, pH and resistivity is not greater than the limits corresponding to the Pipe Class in Table 206-1 or 206-2 for the pipe class specified on the plans. No single test shall have a result more than 20 percent greater than that corresponding to the limit in Table 206-1 or Table 206-2 for sulfates, chlorides and resistivity. No single test shall have a result more than 5 percent outside the limit in Table 206-1 for pH. The remaining sample material from a single failing test shall be split into three equal portions. CDOT shall receive one portion, the Contractor shall receive one portion, and the remaining portion shall be retained by the Project. CDOT and the Contractor's Lab shall retest the failed sample; if the results from those tests are within 10 percent of each other, the results will be averaged. The averaged result will be used for Contract compliance. If the results from the Labs are not within 10 percent of each other, the remaining sample portion will be sent to an independent laboratory for testing using the testing requirements specified above. The independent laboratory shall be mutually agreed upon by the Department and the Contractor. The Independent Lab's test result will be used for Contract compliance.

If the imported material's sulfates, chlorides, and resistivity are less than the limits and the pH is within the limits in Table 206-1 or 206-2, CDOT will bear all costs associated with the independent lab test. If the imported material's sulfates, chlorides, and resistivity is greater than the limits and the pH is outside the limits in Table 206-1 or 206-2, all costs associated with independent lab testing shall be at the Contractor's expense.

Structure backfill represented by failing tests shall be removed from the project and replaced at the Contractor's expense.

Table 206-1
SULFATE, CHLORIDE AND PH OF IMPORTED MATERIAL

	SOIL		
Pipe Class	Sulfate (SO_4) % max	Chloride (Cl) % max	pH
0 , 7	0.05	0.05	6.0-8.5
1, 7	0.10	0.10	6.0-8.5
2, 8	0.20	0.20	6.0-8.5
3, 9	0.50	0.50	6.0-8.5
4, 9	1.00	1.00	5.0-9.0
5, 10	2.00	2.00	5.0-9.0
6, 10	>2.00	>2.00	<5 or >9

Figure 3.8 - CDOT Section 206, Excavation and Backfill for Structures, Page 206
Original content by CDOT

Table 206-2
RESISTIVITY AND PH OF IMPORTED MATERIAL

SOIL SIDE	
Resistivity, R (Ohm – cm)	pH
≥1,500	5.0-9.0
≥250	3.0-12.0

(b) *Bed Course Material*. Material shall conform to the requirements of subsection 703.07. Upon approval, aggregate base course conforming to the requirements of subsection 703.03 may be used in lieu of bed course material.

(c) *Filter Material*. Class A, Class B, and Class C Filter Material shall conform to the requirements of subsection 703.09. Class of material shall be as specified or designated.

CONSTRUCTION REQUIREMENTS

206.03 Structure Excavation and Structure Backfill. Unsuitable foundation material shall be removed and wasted in a manner acceptable to the Engineer, and the excavated material will be paid for as structure excavation. Excavation and backfill for areas in excess of 3 feet below designed elevation will be paid for as provided in subsections 104.03 and 109.04. Unsuitable foundation material which is suitable for embankments and suitable surplus excavated material shall be used in the construction of embankments. Unsuitable material removed below designed elevation shall be replaced with approved material.

If asbestos containing material (ACM) is suspected or found, the ACM and the suspected ACM shall be managed in accordance with the Air Quality Control Commission Regulation No. 8 Part B or Section 5.5 of the solid Waste Regulation 6 CCR 1007-2, which ever applies. All work conducted on site shall be in accordance with the Colorado Department of Public Health and Environment's Asbestos-Contaminated Soil Guidance Document or the State of Colorado's Asbestos Contaminated Soil Statewide Management Plan (ACS), whichever is more recent at the time of advertisement, and in accordance with subsection 250.07(d).

Rock, hardpan, or other unyielding material encountered in trenches for culvert pipe or conduit shall be removed below the designed grade for a minimum depth of 12 inches. This extra depth excavation shall be backfilled with loose Structure Backfill (Class 1) or other approved material. The base of structure backfill shall be scarified to a depth of 6 inches and compacted with moisture and density control prior to placement of any structural element or structure backfill. The type of compaction shall be the same as that required for Structure Backfill (Class 2), as specified below.

Figure 3.10 - CDOT Section 206, Excavation and Backfill for Structures, Page 207
Original content by CDOT

206.03

Backfill shall consist of approved materials uniformly distributed in layers brought up equally on all sides of the structure. Each layer of backfill shall not exceed 6 inches and shall be compacted to the required density before successive layers are placed.

Structure Backfill (Class 1) shall be compacted to a density of at least 95 percent of maximum dry density determined in accordance with AASHTO T 180 as modified by CP 23. Backfill shall be compacted at ± 2 percent of Optimum Moisture Content (OMC).

Structure Backfill (Class 2) shall be compacted to a density of at least 95 percent of maximum dry density. The maximum dry density and OMC for A-1, A-2-4. A-2-5 and A-3 materials will be determined in accordance with AASHTO T 180 as modified by CP 23. The maximum dry density and OMC for all other materials will be determined in accordance with AASHTO T 99 as modified by CP 23. Materials shall be compacted at ± 2percent of Optimum Moisture Content (OMC). Materials having greater than 35 percent passing the 75 µm (No. 200) sieve shall be compacted at 0 to 3 percent above OMC.

Pipes, culverts, sewers, and other miscellaneous structures outside the roadway prism and not subjected to traffic loads shall be backfilled in layers as described above but shall be compacted to the density of the surrounding earth.

The excessive use of water during backfilling operations will not be permitted.

Compaction equipment or methods that produce horizontal or vertical earth pressures, which may cause excessive displacement or overturning, or may damage structures, shall not be used.

Backfill material shall not be deposited against newly constructed masonry or concrete structures, until the concrete has developed a compressive strength of 0.8f'c, except in cases where the structures support lateral earth pressure. Concrete compressive strength for structures supporting lateral earth pressure shall conform to subsection 601.12(o). Concrete compressive strength shall be determined by maturity meters.

Backfill at the inside of bridge wingwalls and abutments shall be placed before curbs or sidewalks are constructed over the backfill and before railings on the wingwalls are constructed.

Unless otherwise indicated in the Contract or directed, all sheeting and bracing used in making structure excavation shall be removed by the Contractor prior to backfilling.

Structure backfill placed at bridge piers in waterways and water channels, that does not support embankments, pavements, or slope protection, will not require compaction.

Structure Backfill (Flow-Fill) shall not be compacted.

The maximum layer thickness for Structure Backfill (Flow-Fill) shall be 3 feet unless otherwise approved by the Engineer. The Contractor shall not place

Figure 3.11 - CDOT Section 206, Excavation and Backfill for Structures, Page 208
Original content by CDOT

Structure Backfill (Flow-Fill) in layers that are so thick that they cause damage to culverts, pipes, and other structures or that they cause formwork or soil failures during placement. Structure Backfill (Flow-Fill) shall have an indention diameter less than 3 inches and the indention shall be free of visible water when tested in accordance with ASTM D6024 by the Contractor prior to placing additional layers of Structure Backfill (Flow-Fill).Testing Structure Backfill (Flow-Fill) in accordance with ASTM D6024 will be witnessed by the Engineer. Damage resulting from placing Structure Backfill (Flow-Fill) in layers that are too thick or from not allowing sufficient time between placements of layers shall be repaired at the Contractor's expense.

The Contractor shall secure culverts, pipes and other structures to prevent floating and displacement of these items during the placement of the Structure Backfill (Flow-Fill).

Prior to the placement of Structure Backfill (Flow-Fill), the Contractor shall sample the Structure Backfill (Flow-Fill) in accordance with ASTM D5971. The Contractor shall test the Structure Backfill (Flow-Fill) unit weight in accordance with ASTM D6023. The Contractor shall test the Structure Backfill (Flow-Fill) for slump in accordance with ASTM C143 or for flow consistency according to ASTM D6103.

The Contractor shall sample and test the first three loads of Structure Backfill (Flow-Fill) for each placement and then randomly once every 50 cubic yards. Sampling and testing will be witnessed by the Engineer

When Structure Backfill (Flow-Fill) is placed in areas that require future excavation, the unit weight of the placed Structure Backfill (Flow-Fill) shall not exceed the unit weight of the approved mix design by more than 2.0 pounds per cubic foot.

Structure Backfill (Flow-Fill) shall not be allowed to freeze during placement and until it has set sufficiently according to ASTM D6024. Frozen Structure Backfill (Flow-Fill) shall be removed and replaced at the Contractor's expense.

When the Contractor substitutes Structure Backfill (Flow-Fill) for Structure Backfill (Class 1) or (Class 2), the trench width may be reduced to provide a minimum 6 inch clearance between the outside diameter of the culvert and the trench wall.

206.04 Bed Course Material. Construction requirements for bed course material for sidewalks and curbing shall conform to the applicable requirements of Sections 608 and 609.

206.05 Filter Material. Construction requirements for filter material for subsurface drains shall conform to the applicable requirements of Section 605.

Filter material shall be placed behind bridge abutments, wingwalls, and retaining walls as provided in the Contract and in accordance with the following requirements:

Figure 3.12 - CDOT Section 206, Excavation and Backfill for Structures, Page 209
Original content by CDOT

206.06

When provided in the Contract, wall drain outlets shall be backed with sacked filter material conforming to the gradation requirements for coarse aggregate No. 3 or No. 4 set forth in Table 703-2.

Filter material shall be placed in horizontal layers along with and by the same methods specified for structure backfill.

METHOD OF MEASUREMENT

206.06 Structure excavation, structure backfill, and bed course material will not be measured but will be the quantities designated in the Contract. When field changes are ordered or when there are errors on the plans, quantities will be measured as follows:

(a) For bridges and irregular shaped structures, quantities will be computed to neat lines 18 inches outside and parallel to the outline of the revised foundation plan or as shown on the plans.

(b) For pipes, a profile will be made along the bottom of the center line extending 18 inches beyond the end of the structure, including end sections. Material excavated between this profile and a profile 1 foot above the top of the pipe will not be measured for payment, but shall be included in the bid price for the pipe. In excavation sections the area above the profile 1 foot above the top of the pipe and below the limits of roadway excavation will be multiplied by the width shown on the plans to obtain the volume of structure excavation measured for payment. In embankment sections the area above the profile 1 foot above the top of the pipe and below the natural ground will be multiplied by the width shown on the plans to obtain the volume of structure excavation measured for payment.

(c) Backfill and filter material will be the calculated volume of material lying within the prism shown on the plans, from which shall be deducted the volume occupied by the structure.

(d) Bed course material will be the calculated volume of material lying within the prism shown on the plans.

Figure 3.13 - CDOT Section 206, Excavation and Backfill for Structures, Page 210
Original content by CDOT

3.3 Erosion Control

Erosion control is necessary for any project causing ground disturbance where sediment may be transported into the project area, off site, into drainages or waterways, or onto pavements. Sediment control fence is to be installed on the downhill boundary of the disturbed area during the course of construction and maintained in place until soil has been stabilized by revegetation or installation of permanent erosion control features. Wattles or bales may be used to protect flowlines of swales, inlets, or to provide intermittent transverse control along contours of a large slope. Individual jurisdictions may have specific requirements for temporary erosion control, including municipalities and at the state level (SWMP permit). A site-specific temporary erosion control plan should be developed for each individual project.

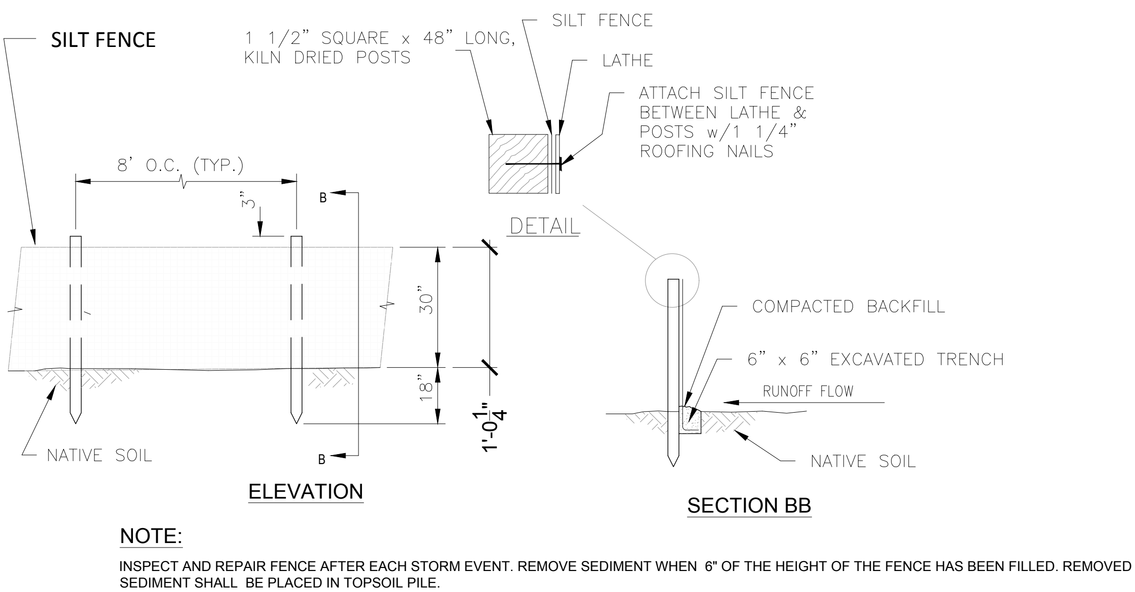


Figure 3.14 - Sediment Control Fence
Original detail by DHM Design

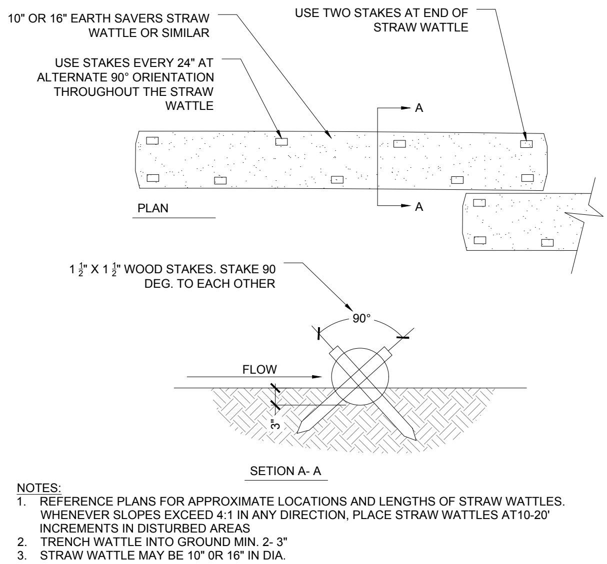


Figure 3.15 - Wattle Check Dam For Swale or Mid-slope
Original detail by DHM Design

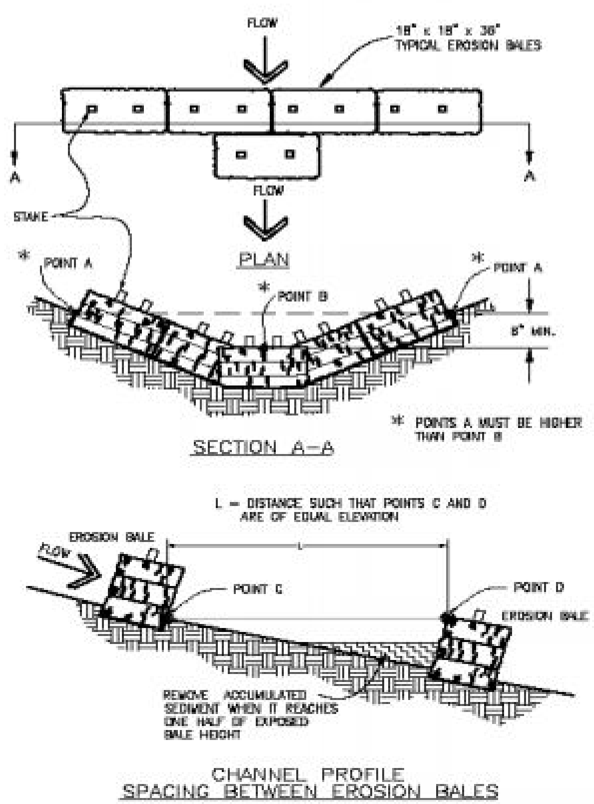


Figure 3.16 - Bale Erosion Check Damn
Original detail by CDOT Erosion Control and Stormwater Quality Field Guide

4 Retaining Walls

Retaining walls may be necessary in the corridor in response to a variety of conditions: slope retention above or below the trail as necessary to provide an appropriate trail section, in response to erosion of existing slopes in the corridor, to avoid disturbance of sensitive areas (such as wetlands or existing utilities), and at bridge abutments, underpasses or other crossings. When choosing the material for a retaining wall, consider the context of the project (is it near, and can it complement, existing infrastructure; is it within a town boundary/urban context or more rural), the access to the project area (eg, will it be difficult to access the site with heavy equipment), the geotechnical soil conditions, the size of the wall (length and height) and any limitations on disturbance or excavation for the required wall.

Given that the trail corridor is largely within a rural context, the preference is for retaining walls to be of natural materials with a rural or rustic character. Within town jurisdictions or near existing development, more refined materials and design aesthetics may be appropriate. Acceptable wall materials include: dry stacked boulders, dry stacked quarried stone, landscape timbers, timber cribbing, precast concrete block, cast-in-place concrete, gabion basket. Each wall type is described below. Site conditions may dictate that other retaining structures be used, such as soil nail and shotcrete walls. The use of other wall types will be reviewed on a case-by-case basis by RFTA staff and may require geotechnical evaluation and design by a licensed engineer.

Note that these details are provided as illustrative examples only. Retaining wall design may require specific calculation and specification by a qualified engineer, and must meet the overlying jurisdictional requirements for design, permitting, and construction.

4.1 Boulder Wall

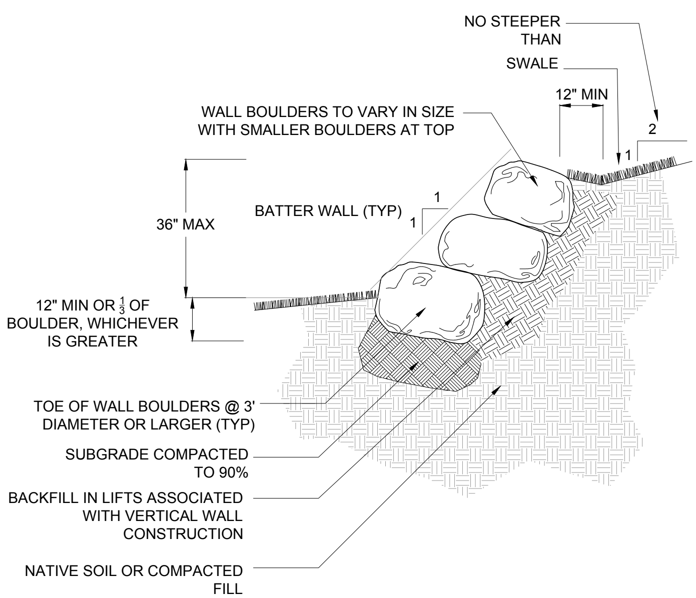
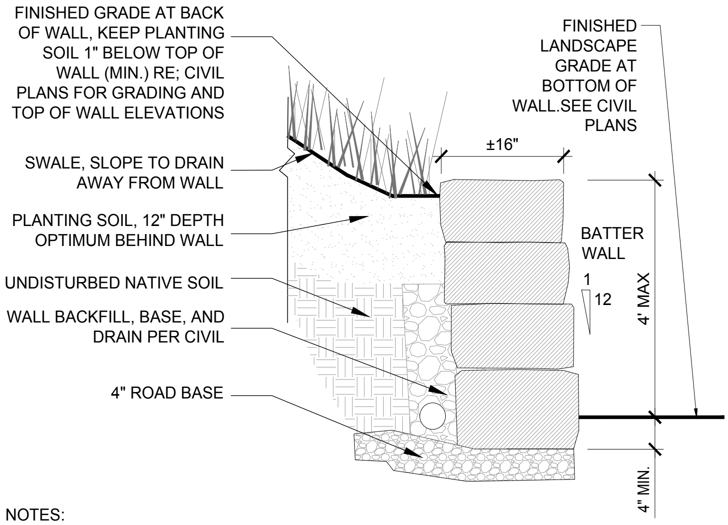


Figure 4.1 - Boulder Wall
Original detail by DHM Design.

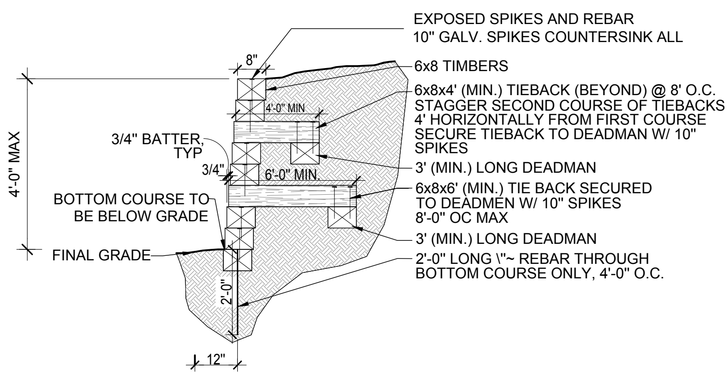
4.2 Dry Stacked Quarried Stone Wall



NOTES:
1. STONE COURSING IS TO BE LEVEL AND STEP WITH GRADE.
2. VERTICAL JOINTS TO BE RANDOM OFFSET.
3. ACCEPTABLE STONE PROPORTIONS: LENGTH = 3X HEIGHT (MIN).
4. WALL ALIGNMENT TO BE STAKED IN FIELD AND APPROVED BY LANDSCAPE ARCHITECT PRIOR TO CONSTRUCTION.
7. WALL SHOULD NOT EXCEED 48" IN HT. SEE CIVIL PLANS FOR GRADING AND TOP OF WALL ELEVATIONS

Figure 4.2 - Quarried Stone Wall
Original detail by DHM Design.

4.3 Landscape Timber Wall



NOTES:
1. ALL TIMBERS WILL BE 6"x8"x8' SELECT, PRESSURE TREATED, FREE OF MAJOR SURFACE DEFECTS, CRACKS & WARPAGE.
2. EACH 8'-0" LENGTH OF TIMBER TO RECEIVE A MINIMUM OF FOUR (4)- 10" GALVANIZED SPIKES (MIN. 2' O.C.). SHORT LENGTHS WILL RECEIVE AS MANY SPIKES AS NECESSARY TO PROPERLY SECURE TIMBERS. STAGGER TIMBERS AT JOINTS 2'-0" MIN.

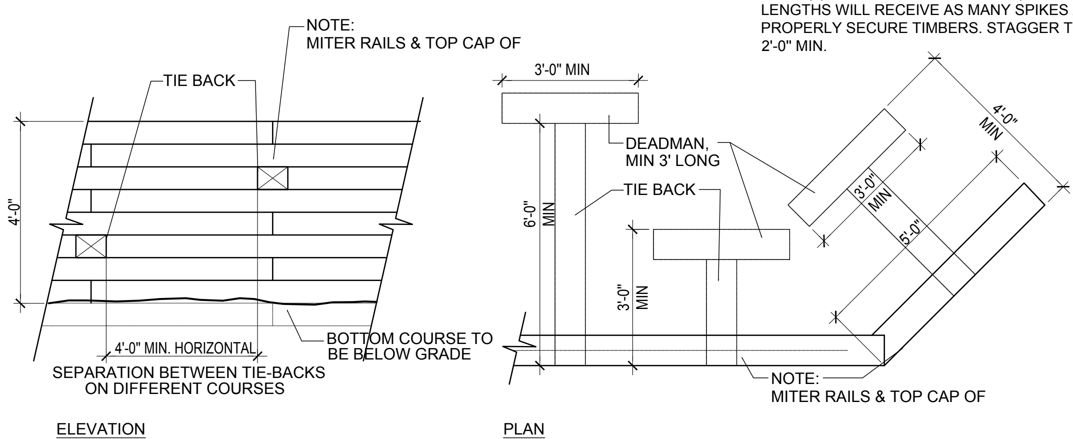


Figure 4.3 - Landscape Timber Wall
Original detail by DHM Design.

4.4 Timber Cribbing

Timber crib walls can be an acceptable and effective alternative to solid timber landscape, block, and concrete walls. A crib wall is a gravity system, relying on the mass of the granular fill of the crib to provide structural stability. This wall generally does not require a foundation can be installed by unskilled labor, and the timber materials generally can be placed by hand or with the aid of small equipment (except in the case of very tall walls). Aesthetically, crib walls create a rustic or industrial character, and can be designed to include plant material in the wall face. This system can be installed in a (segmented) curvilinear alignment, which can be an advantage over solid-faced timber walls.

Timber crib walls are appropriate for use in slope retention and bridge abutment applications. The type of timber treatment will vary based on the application, and fasteners specific to the chemical treatment of the timbers are required.

Timber crib walls are constructed of 6x6 or 8x8 treated landscape timbers, backfilled with 4-8" washed river rock (granular ballast). Granular material is contained at the wall face by galvanized welded wire fabric (WWF) of a size to contain the ballast. Timbers are fixed with 12" timber spikes treated for use in treated lumber. Alternately, timber screws (such as Timberlok) approved for use in treated timbers are acceptable.

Timbers used for walls should meet or exceed requirements of the American Wood Protection Association (APWA) standards for Use Category System UC4B or UC4C.

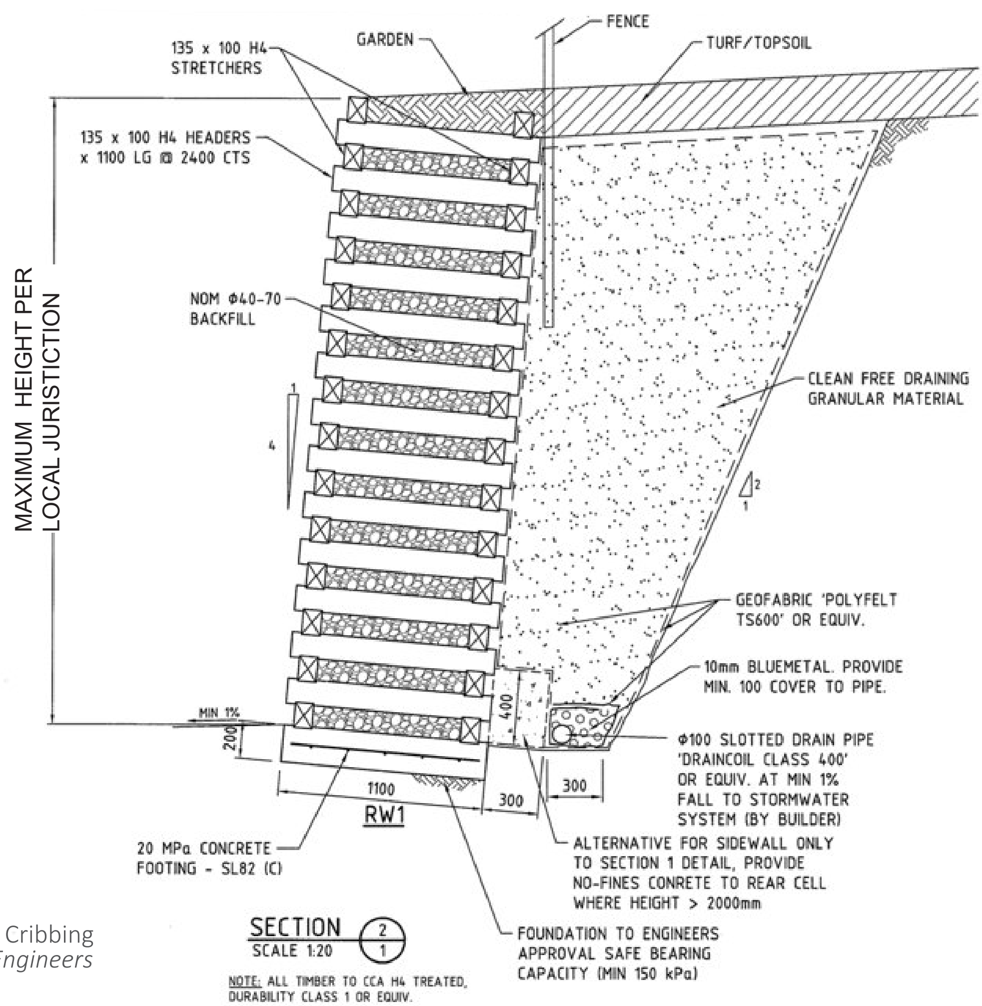


Figure 4.4 - Timber Cribbing
Original detail by csg Engineers

4.5 Precast Block Landscape Wall

Precast block walls should be limited to developed/urban contexts where other developed amenities exist or are planned (picnic shelters, park furniture, buildings, plazas). The typical character for the precast block material is to be Keystone 6" BroadStone 'rock face' in Three-Tone Brown color, or similar as provided by other manufacturers and approved by RFTA. Form factor and color of precast block may be evaluated on an individual project basis to be responsive to the project context.

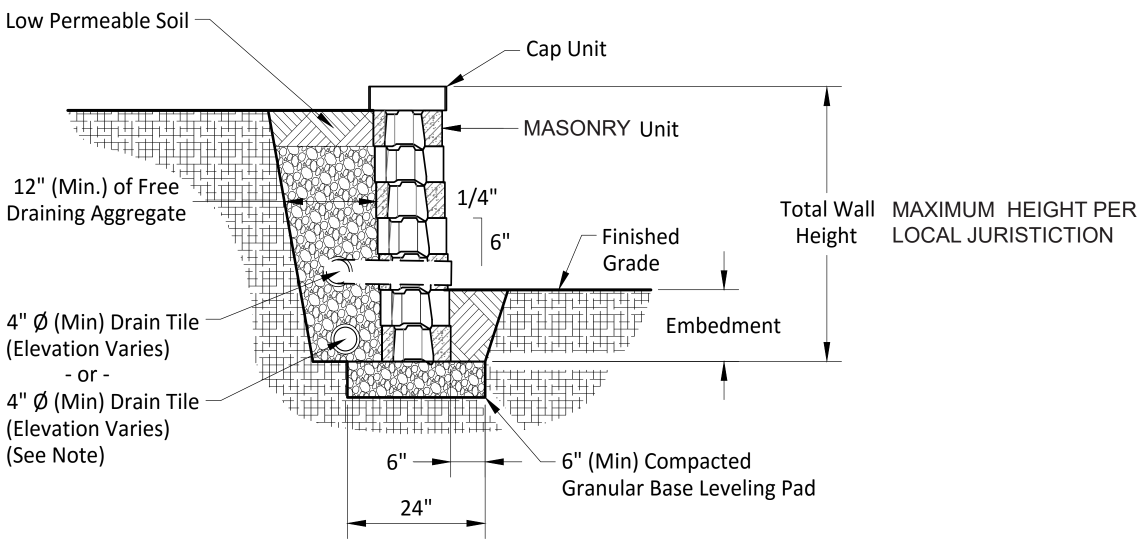


Figure 4.5 - Precast Masonry Landscape Wall
Keystone Retaining Walls standard detail.

4.6 Precast Block Mechanically Stabilized Earth (MSE) Wall - Typical

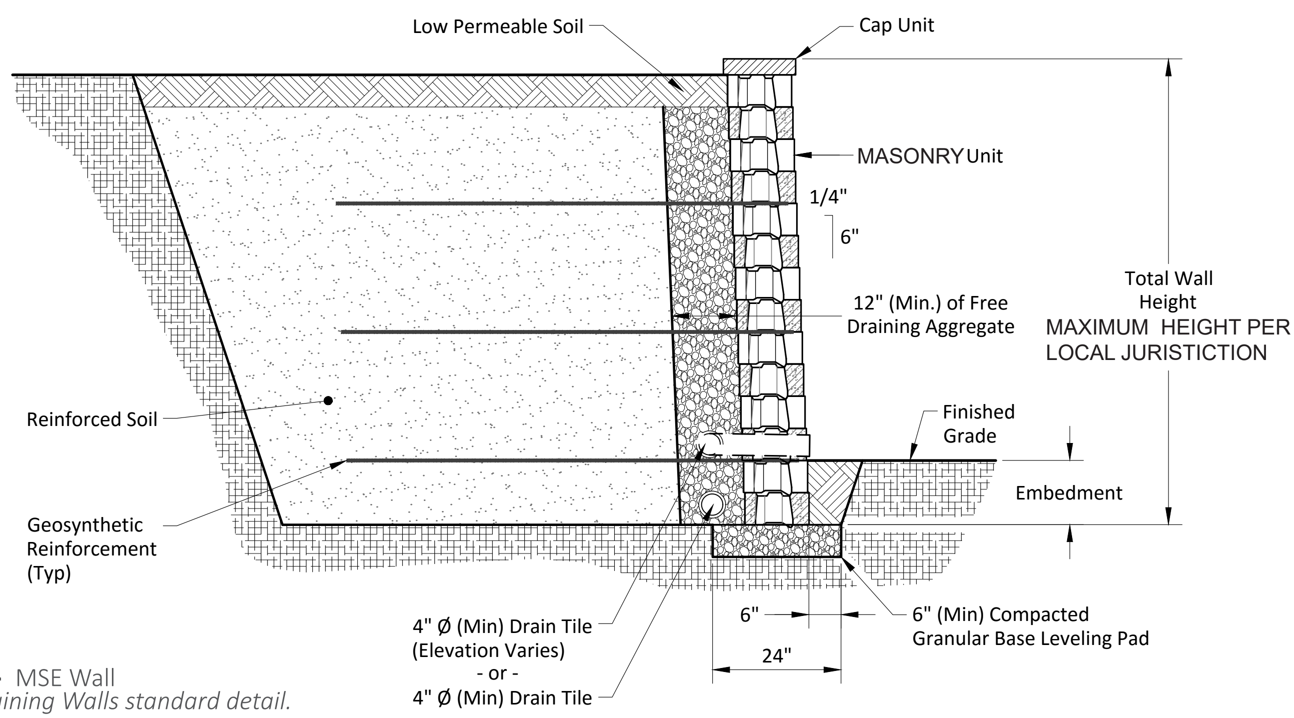


Figure 4.6 - MSE Wall
Keystone Retaining Walls standard detail.

4.7 Precast Block Mechanically Stabilized Earth (MSE) Wall - Trail Context

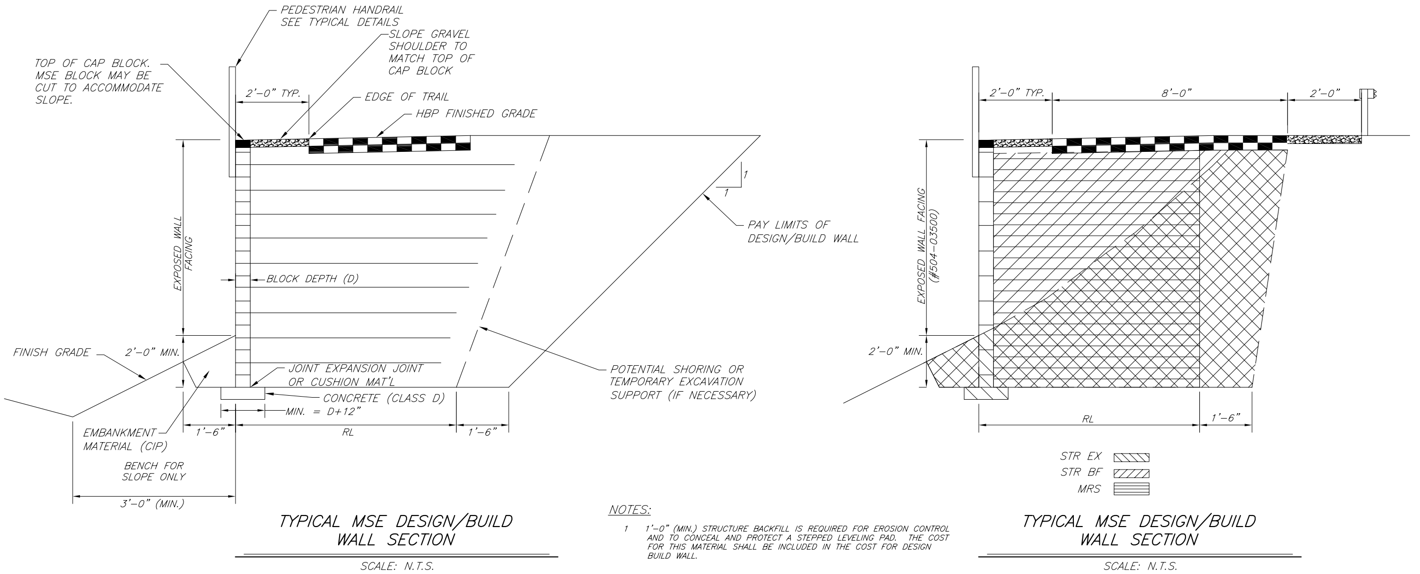


Figure 4.7 - MSE Wall
Detail Provided by RFTA. Original detail by SGM.

4.8 MSE Wall - Gabion Basket

Gabions may function as a non-structural landscape wall or as facing of a MSE wall system. The aesthetics of a gabion wall can support a rustic/industrial character or a contemporary style. The use of gabions in the corridor should be limited to special circumstances where the design character of the gabion baskets fits into a larger aesthetic program. Gabion baskets are to be 3"x3", 9 gauge plain steel WWF. Gabion ballast should be regionally-sourced, washed river cobble, well-graded between 4" and 8" material.

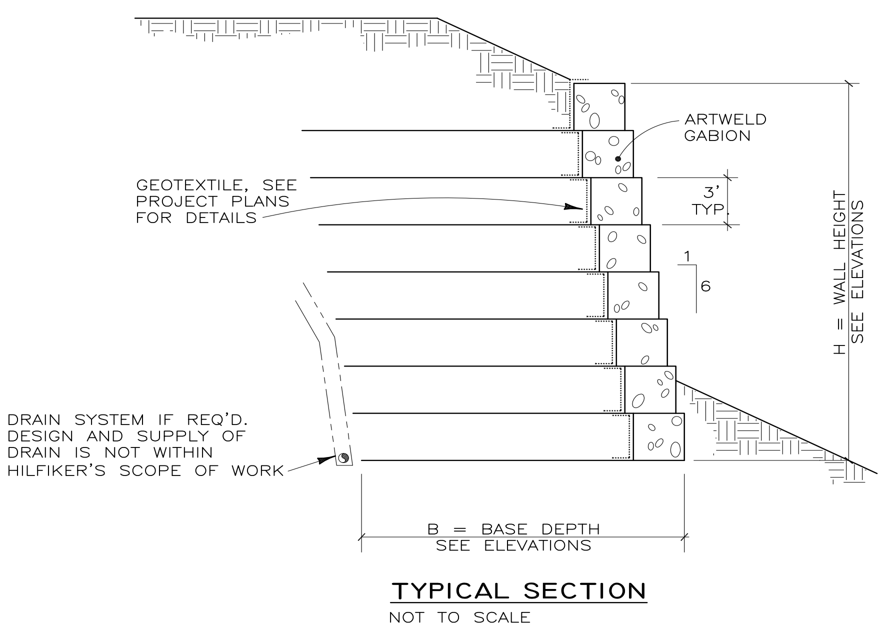


Figure 4.8 - MSE Wall- Gabion Basket
Original detail by Hilfiker Retaining Walls.

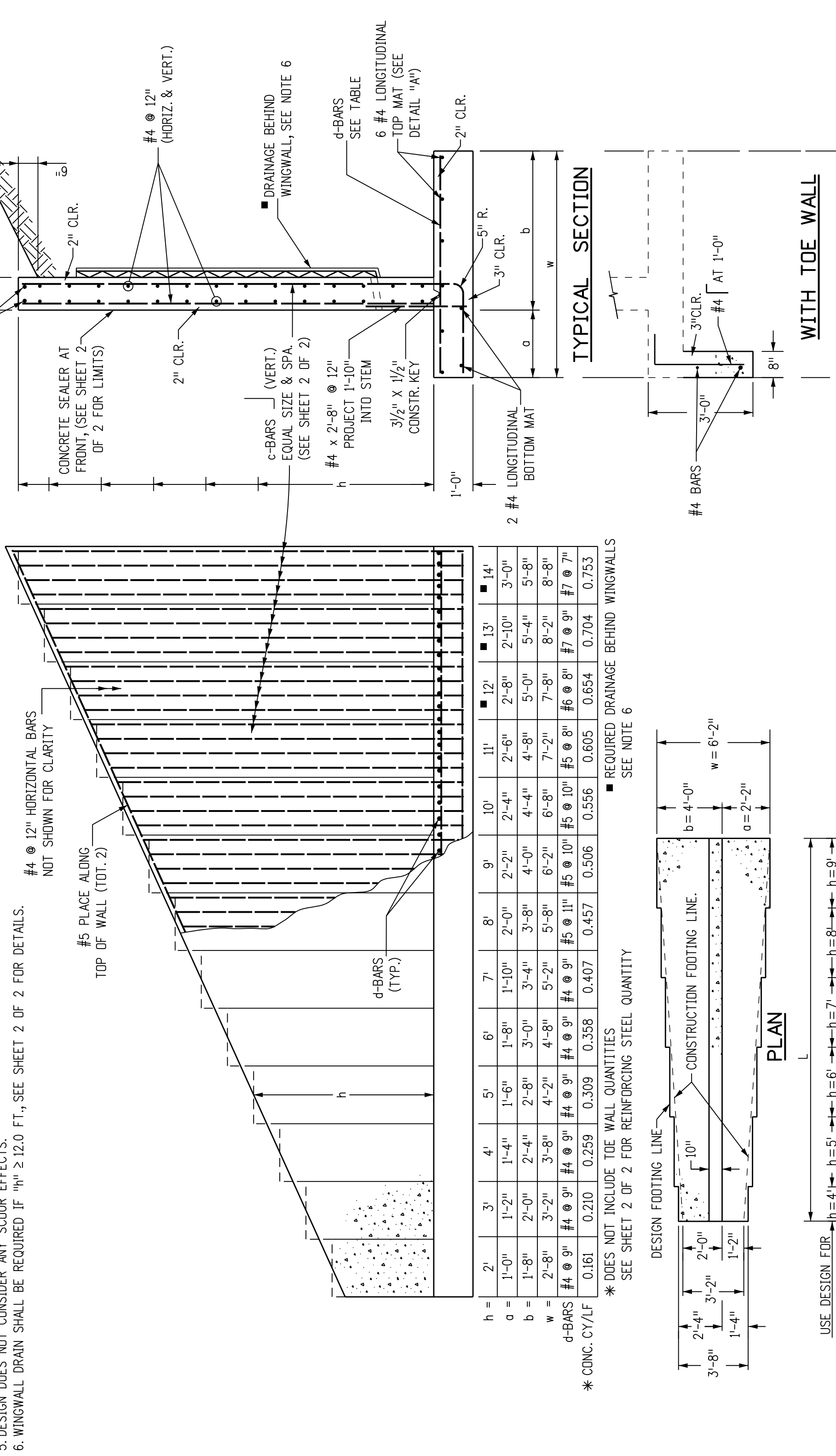
4.9 Cast-in-Place Concrete Wall

GENERAL NOTES:

1. ALL EXPOSED CONCRETE CORNERS SHALL BE CHAMFERED ¾ IN.
2. WINGWALL FOOTING AND FLOOR OF BOX CULVERT SHALL BE PLACED MONOLITHICALLY.
3. DIMENSIONS "h", "k", "L", "m" AND ANGLE "θ" FOR WINGWALL SHALL BE AS SHOWN ON THE PLANS.
4. MINIMUM CLASS B LAP SPLICE LENGTH FOR BLACK REINFORCING BARS:

BAR SIZE:	#4	#5	#6	#7
SPLICE LENGTH:	1'-6"	1'-11"	2'-3"	2'-7"

5. DESIGN DOES NOT CONSIDER ANY SCOUR EFFECTS.
6. WINGWALL DRAIN SHALL BE REQUIRED IF "h" ≥ 12.0 FT., SEE SHEET 2 OF 2 FOR DETAILS.



h =	2'	3'	4'	5'	6'	7'	8'	9'	10'	11'	■ 12'	■ 13'	■ 14'
a =	1'-0"	1'-2"	1'-4"	1'-6"	1'-8"	1'-10"	2'-0"	2'-2"	2'-4"	2'-6"	2'-8"	2'-10"	3'-0"
b =	1'-8"	2'-0"	2'-4"	2'-8"	3'-0"	3'-4"	3'-8"	4'-0"	4'-4"	4'-8"	5'-0"	5'-4"	5'-8"
w =	2'-8"	3'-2"	3'-8"	4'-2"	4'-8"	5'-2"	5'-8"	6'-2"	6'-8"	7'-2"	7'-8"	8'-2"	8'-8"
d-BARS	#4 @ 9"	#4 @ 9"	#4 @ 9"	#4 @ 9"	#4 @ 9"	#4 @ 9"	#5 @ 11"	#5 @ 10"	#5 @ 10"	#5 @ 8"	#6 @ 8"	#7 @ 9"	#7 @ 7"
✱ CONC. CY/LF	0.161	0.210	0.259	0.309	0.358	0.407	0.457	0.506	0.556	0.605	0.654	0.704	0.753

✱ DOES NOT INCLUDE TOE WALL QUANTITIES
SEE SHEET 2 OF 2 FOR REINFORCING STEEL QUANTITY

■ REQUIRED DRAINAGE BEHIND WINGWALLS
SEE NOTE 6

DESIGN DATA:

AASHTO LRFD EIGHTH EDITION, 2017
DESIGN METHOD: LOAD AND RESISTANCE FACTOR DESIGN, YIELD LINE METHOD

REINFORCED CONCRETE:
CONCRETE CLASS D (BOX CULVERT): f'_c = 4,500 PSI
REINFORCING STEEL: f_y = 60,000 PSI

LOADING:
AT-REST EARTH (FLUID) PRESSURE FOR CONCRETE STEM DESIGN = 55 PCF FOR 2 (MIN.):1 SLOPED BACKFILL
ACTIVE EARTH (FLUID) PRESSURE FOR CONCRETE FOOTING DESIGN = 40 PCF FOR 2 (MIN.):1 SLOPED BACKFILL
LIVE LOAD SURCHARGE = 2'
MINIMUM RESISTANCE FOR SOIL BEARING = 5.5 KSF
SOIL BEARING RESISTANCE FACTOR = 0.45

Figure 4.9 - Reinforced Concrete Walls
Excerpted from CDOT Standard Plan No. M-601-20; 1 of 2

c-BARS AND REINFORCING STEEL QUANTITY (EXCLUDE TOE WALL)

∗ REINFORCING STEEL QUANTITY INCLUDES STEM AND FOOTING QUANTITIES, BUT DOES NOT INCLUDE TOE WALL QUANTITIES.

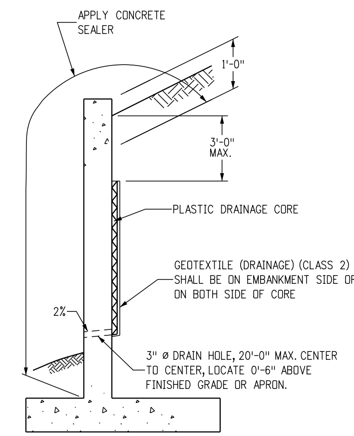
L (MULTIPLE OF m)		≤ (1.0 x m)		≤ (1.25 x m)		≤ (1.5 x m)		≤ (1.75 x m)		≤ (2.0 x m)		≤ (2.25 x m)		≤ (2.5 x m)		≤ (2.75 x m)		≤ (3.0 x m)		≤ (3.25 x m)		≤ (3.5 x m)	
m (FT)	k (FT)	c-BARS	∗ REINF. LB./L.F.	c-BARS	∗ REINF. LB./L.F.	c-BARS	∗ REINF. LB./L.F.	c-BARS	∗ REINF. LB./L.F.	c-BARS	∗ REINF. LB./L.F.	c-BARS	∗ REINF. LB./L.F.	c-BARS	∗ REINF. LB./L.F.	c-BARS	∗ REINF. LB./L.F.	c-BARS	∗ REINF. LB./L.F.	c-BARS	∗ REINF. LB./L.F.	c-BARS	∗ REINF. LB./L.F.
14	4	#4 @ 10"	53.60	#5 @ 10"	57.95	#5 @ 10"	57.10	#5 @ 8"	60.22	#5 @ 7"	62.43	#5 @ 7"	62.09	#5 @ 6"	65.38	#5 @ 6"	65.15	#6 @ 8"	67.10	#6 @ 8"	66.94	#6 @ 7"	70.66
	5	#4 @ 10"	55.86	#5 @ 10"	60.46	#5 @ 10"	59.60	#5 @ 8"	62.89	#5 @ 7"	65.23	#5 @ 7"	64.88	#5 @ 6"	68.34	#5 @ 6"	68.11	#6 @ 8"	70.17	#6 @ 8"	70.00	#6 @ 7"	73.90
	6	#5 @ 10"	64.43	#6 @ 10"	70.60	#6 @ 10"	69.69	#6 @ 8"	74.93	#6 @ 8"	74.45	#6 @ 7"	78.30	#6 @ 6"	83.64	#6 @ 6"	83.40	#6 @ 6"	83.22	#6 @ 6"	83.05	#7 @ 7"	89.64
	7	#5 @ 10"	67.29	#6 @ 10"	73.76	#6 @ 10"	72.83	#6 @ 8"	78.32	#6 @ 8"	77.84	#6 @ 7"	81.87	#6 @ 6"	87.45	#6 @ 6"	87.21	#6 @ 6"	87.02	#6 @ 6"	86.86	#7 @ 7"	93.73
	8	#5 @ 8"	74.71	#6 @ 8"	83.46	#6 @ 7"	87.09	#6 @ 6"	92.54	#7 @ 7"	99.47	#7 @ 7"	99.08	#7 @ 6"	107.11	#7 @ 6"	106.86	#7 @ 6"	106.66	#7 @ 6"	106.49	#7 @ 6"	106.35
	9	#5 @ 8"	78.10	#6 @ 8"	87.23	#6 @ 7"	91.03	#6 @ 6"	96.72	#7 @ 7"	103.93	#7 @ 7"	103.54	#7 @ 6"	111.90	#7 @ 6"	111.65	#7 @ 6"	111.45	#7 @ 6"	111.28	#7 @ 6"	111.13
13	4	#4 @ 10"	50.51	#4 @ 10"	49.25	#5 @ 10"	53.71	#5 @ 10"	53.09	#5 @ 10"	52.36	#5 @ 9"	53.85	#5 @ 8"	55.54	#5 @ 7"	57.85	#5 @ 7"	57.67	#5 @ 7"	57.51	#6 @ 9"	59.93
	5	#4 @ 10"	52.66	#4 @ 10"	51.37	#5 @ 10"	56.09	#5 @ 10"	55.46	#5 @ 10"	54.99	#5 @ 9"	56.29	#5 @ 8"	58.08	#5 @ 7"	60.51	#5 @ 7"	60.33	#5 @ 7"	60.17	#6 @ 9"	62.72
	6	#4 @ 10"	54.92	#5 @ 10"	59.48	#5 @ 9"	60.31	#6 @ 9"	67.56	#6 @ 9"	67.08	#6 @ 9"	66.70	#6 @ 8"	69.53	#6 @ 8"	69.28	#6 @ 7"	73.12	#6 @ 7"	72.95	#6 @ 7"	72.81
	7	#4 @ 10"	57.36	#5 @ 10"	62.16	#5 @ 9"	63.05	#6 @ 9"	70.66	#6 @ 9"	70.16	#6 @ 9"	69.78	#6 @ 8"	72.75	#6 @ 8"	72.50	#6 @ 7"	76.52	#6 @ 7"	76.35	#6 @ 7"	76.20
	8	#5 @ 10"	66.39	#6 @ 10"	72.82	#6 @ 8"	77.97	#6 @ 7"	81.68	#6 @ 7"	81.19	#6 @ 6"	86.67	#6 @ 6"	86.37	#7 @ 7"	93.18	#7 @ 7"	92.97	#7 @ 7"	92.80	#7 @ 7"	92.64
	9	#5 @ 10"	69.37	#6 @ 10"	76.10	#6 @ 8"	81.49	#6 @ 7"	85.37	#6 @ 7"	84.87	#6 @ 6"	90.59	#6 @ 6"	90.29	#7 @ 7"	97.39	#7 @ 7"	97.18	#7 @ 7"	97.00	#7 @ 7"	96.85
12	2	#4 @ 10"	43.91	#4 @ 10"	42.65	#4 @ 10"	41.82	#4 @ 10"	41.22	#4 @ 10"	40.78	#4 @ 9"	41.29	#5 @ 10"	44.61	#5 @ 10"	44.37	#5 @ 10"	44.18	#5 @ 10"	44.01	#5 @ 10"	43.87
	3	#4 @ 10"	45.82	#4 @ 10"	44.55	#4 @ 10"	43.71	#4 @ 10"	43.11	#4 @ 10"	42.66	#4 @ 9"	43.22	#5 @ 10"	46.75	#5 @ 10"	46.51	#5 @ 10"	46.32	#5 @ 10"	46.15	#5 @ 10"	46.01
	4	#4 @ 10"	47.80	#4 @ 10"	46.51	#4 @ 10"	45.65	#5 @ 10"	50.06	#5 @ 10"	49.59	#5 @ 10"	49.23	#5 @ 10"	48.94	#5 @ 10"	48.69	#5 @ 9"	50.00	#5 @ 8"	51.72	#5 @ 8"	51.57
	5	#4 @ 10"	49.84	#4 @ 10"	48.53	#4 @ 10"	47.66	#5 @ 10"	52.33	#5 @ 10"	51.85	#5 @ 10"	51.48	#5 @ 10"	51.19	#5 @ 10"	50.94	#5 @ 9"	52.33	#5 @ 8"	54.14	#5 @ 8"	54.00
	6	#4 @ 10"	51.99	#4 @ 10"	50.65	#5 @ 10"	55.34	#5 @ 8"	58.41	#5 @ 8"	57.93	#6 @ 10"	60.60	#6 @ 10"	60.29	#6 @ 9"	62.42	#6 @ 9"	62.22	#6 @ 9"	62.04	#6 @ 8"	64.89
	7	#4 @ 10"	54.30	#5 @ 10"	58.80	#5 @ 10"	57.87	#5 @ 8"	61.10	#5 @ 8"	60.61	#6 @ 10"	63.43	#6 @ 10"	63.11	#6 @ 9"	65.35	#6 @ 9"	65.15	#6 @ 9"	64.97	#6 @ 8"	67.96
	8	#5 @ 10"	62.91	#5 @ 10"	61.45	#5 @ 7"	67.46	#5 @ 6"	70.68	#5 @ 6"	70.20	#6 @ 7"	76.44	#6 @ 7"	76.13	#6 @ 7"	75.87	#6 @ 6"	81.30	#6 @ 6"	81.12	#6 @ 6"	80.98
	9	#5 @ 10"	65.64	#5 @ 10"	64.15	#5 @ 7"	70.44	#5 @ 6"	73.82	#5 @ 6"	73.33	#6 @ 7"	79.86	#6 @ 7"	79.54	#6 @ 7"	79.28	#6 @ 6"	84.95	#6 @ 6"	84.77	#6 @ 6"	84.62
11	2	#4 @ 10"	41.70	#4 @ 10"	40.42	#4 @ 10"	39.57	#4 @ 10"	38.96	#4 @ 10"	38.50	#4 @ 10"	38.15	#4 @ 10"	37.87	#4 @ 10"	37.63	#4 @ 9"	38.25	#5 @ 10"	41.46	#5 @ 10"	41.31
	3	#4 @ 10"	43.57	#4 @ 10"	42.27	#4 @ 10"	41.40	#4 @ 10"	40.79	#4 @ 10"	40.33	#4 @ 10"	39.97	#4 @ 10"	39.69	#4 @ 10"	39.45	#4 @ 9"	40.12	#5 @ 10"	43.54	#5 @ 10"	43.39
	4	#4 @ 10"	45.48	#4 @ 10"	44.16	#4 @ 10"	43.28	#4 @ 10"	42.66	#4 @ 9"	43.09	#5 @ 10"	46.57	#5 @ 10"	46.27	#5 @ 10"	46.02	#5 @ 10"	45.82	#5 @ 10"	45.65	#5 @ 10"	45.50
	5	#4 @ 10"	47.46	#4 @ 10"	46.10	#4 @ 10"	45.21	#4 @ 10"	44.58	#4 @ 9"	45.06	#5 @ 10"	48.74	#5 @ 10"	48.44	#5 @ 10"	48.19	#5 @ 10"	47.99	#5 @ 10"	47.81	#5 @ 10"	47.67
	6	#4 @ 10"	49.52	#4 @ 10"	48.14	#4 @ 9"	48.23	#5 @ 10"	51.88	#5 @ 10"	51.38	#5 @ 9"	52.57	#5 @ 9"	52.27	#5 @ 8"	53.99	#5 @ 8"	53.79	#5 @ 7"	56.16	#5 @ 7"	56.01
	7	#4 @ 10"	51.73	#4 @ 10"	50.31	#4 @ 9"	50.43	#5 @ 10"	54.29	#5 @ 10"	53.78	#5 @ 9"	55.04	#5 @ 9"	54.73	#5 @ 8"	56.55	#5 @ 8"	56.35	#5 @ 7"	58.84	#5 @ 7"	58.70
	8	#4 @ 10"	54.00	#5 @ 10"	58.44	#5 @ 10"	57.45	#5 @ 8"	60.64	#5 @ 7"	62.92	#5 @ 6"	66.25	#5 @ 6"	65.94	#5 @ 6"	65.69	#6 @ 8"	67.76	#6 @ 8"	67.57	#6 @ 7"	71.45
	9	#4 @ 10"	56.20	#5 @ 10"	60.87	#5 @ 10"	59.85	#5 @ 8"	63.21	#5 @ 7"	65.60	#5 @ 6"	69.09	#5 @ 6"	68.78	#5 @ 6"	68.52	#6 @ 8"	70.69	#6 @ 8"	70.51	#6 @ 7"	74.57
10	2	#4 @ 10"	39.84	#4 @ 10"	38.53	#4 @ 10"	37.65	#4 @ 10"	37.03	#4 @ 10"	36.57	#4 @ 10"	36.20	#4 @ 10"	35.91	#4 @ 10"	35.67	#4 @ 10"	35.48	#4 @ 9"	36.07	#4 @ 9"	35.93
	3	#4 @ 10"	41.68	#4 @ 10"	40.35	#4 @ 10"	39.47	#4 @ 10"	38.84	#4 @ 10"	38.36	#4 @ 10"	38.00	#4 @ 10"	37.71	#4 @ 10"	37.46	#4 @ 10"	37.27	#4 @ 9"	37.91	#4 @ 9"	37.76
	4	#4 @ 10"	43.58	#4 @ 10"	42.22	#4 @ 10"	41.31	#4 @ 10"	40.67	#4 @ 10"	40.19	#4 @ 10"	39.82	#4 @ 10"	39.53	#4 @ 10"	39.28	#4 @ 10"	39.08	#4 @ 9"	39.77	#4 @ 9"	39.63
	5	#4 @ 10"	45.53	#4 @ 10"	44.14	#4 @ 10"	43.21	#4 @ 10"	42.56	#4 @ 10"	42.07	#5 @ 10"	46.44	#5 @ 10"	46.13	#5 @ 10"	45.87	#5 @ 10"	45.67	#5 @ 10"	45.49	#5 @ 10"	45.34
	6	#4 @ 10"	47.58	#4 @ 10"	46.14	#4 @ 10"	45.20	#4 @ 10"	44.53	#4 @ 10"	44.03	#5 @ 10"	48.67	#5 @ 10"	48.35	#5 @ 10"	48.08	#5 @ 10"	47.88	#5 @ 10"	47.69	#5 @ 10"	47.54
	7	#4 @ 10"	49.79	#4 @ 10"	48.31	#4 @ 10"	47.34	#5 @ 10"	51.97	#5 @ 10"	51.45	#5 @ 10"	51.04	#5 @ 9"	52.29	#5 @ 9"	52.03	#5 @ 8"	53.79	#5 @ 8"	53.61	#5 @ 7"	56.00
	8	#4 @ 10"	52.06	#4 @ 10"	50.54	#4 @ 10"	49.54	#5 @ 10"	54.43	#5 @ 10"	53.89	#5 @ 10"	53.47	#5 @ 9"	54.80	#5 @ 9"	54.53	#5 @ 8"	56.39	#5 @ 8"	56.20	#5 @ 7"	58.72
9	2	#4 @ 10"	38.01	#4 @ 10"	36.75	#4 @ 10"	35.85	#4 @ 10"	35.21	#4 @ 10"	34.73	#4 @ 10"	34.36	#4 @ 10"	34.06	#4 @ 10"	33.81	#4 @ 10"	33.61	#4 @ 10"	33.44	#4 @ 10"	33.30
	3	#4 @ 10"	39.93	#4 @ 10"	38.56	#4 @ 10"	37.64	#4 @ 10"	36.99	#4 @ 10"	36.51	#4 @ 10"	36.13	#4 @ 10"	35.83	#4 @ 10"	35.58	#4 @ 10"	35.38	#4 @ 10"	35.21	#4 @ 10"	35.06
	4	#4 @ 10"	41.81	#4 @ 10"	40.40	#4 @ 10"	39.47	#4 @ 10"	38.81	#4 @ 10"	38.31	#4 @ 10"	37.93	#4 @ 10"	37.63	#4 @ 10"	37.37	#4 @ 10"	37.17	#4 @ 10"	36.99	#4 @ 10"	36.84
	5	#4 @ 10"	43.75	#4 @ 10"	42.30	#4 @ 10"	41.35	#4 @ 10"	40.67	#4 @ 10"	40.17	#4 @ 10"	39.78	#4 @ 10"	39.47	#4 @ 10"	39.20	#4 @ 9"	39.86	#5 @ 10"	43.28	#5 @ 10"	43.12
	6	#4 @ 10"	45.79	#4 @ 10"	44.30	#4 @ 10"	43.31	#4 @ 10"	42.62	#4 @ 10"	42.10	#4 @ 10"	41.71	#4 @ 10"	41.39	#4 @ 10"	41.12	#4 @ 9"	41.82	#5 @ 10"	45.46	#5 @ 10"	45.30
	7	#4 @ 10"	48.04	#4 @ 10"	46.50	#4 @ 10"	45.49	#4 @ 10"	44.77	#5 @ 10"	49.29	#5 @ 10"	48.86	#5 @ 10"	48.53	#5 @ 10"	48.24	#5 @ 10"	48.03	#5 @ 10"	47.84	#5 @ 10"	47.67
	8	#4 @ 10"	50.43	#4 @ 10"	48.84	#4 @ 10"	47.80	#4 @ 10"	47.06	#5 @ 10"	51.83	#5 @ 10"	51.40	#5 @ 10"	51.05	#5 @ 10"	50.77	#5 @ 10"	50.54	#5 @ 10"	50.35	#5 @ 10"	50.18
8	2	#4 @ 10"	36.41	#4 @ 10"	35.01	#4 @ 10"	34.08	#4 @ 10"	33.42	#4 @ 10"	32.92	#4 @ 10"	32.54	#4 @ 10"	32.23	#4 @ 10"	31.97	#4 @ 10"	31.77	#4 @ 10"	31.59	#4 @ 10"	31.44
	3	#4 @ 10"	38.23	#4 @ 10"	36.80	#4 @ 10"	35.85	#4 @ 10"	35.18	#4 @ 10"	34.67	#4 @ 10"	34.28	#4 @ 10"	33.97	#4 @ 10"	33.70	#4 @ 10"	33.50	#4 @ 10"	33.32	#4 @ 10"	33.17
	4	#4 @ 10"	40.09	#4 @ 10"	38.61	#4 @ 10"	37.64	#4 @ 10"	36.95	#4 @ 10"	36.44	#4 @ 10"	36.04	#4 @ 10"	35.72	#4 @ 10"	33.45	#4 @ 10"	35.25	#4 @ 10"	35.07	#4 @ 10"	34.91
	5	#4 @ 10"	41.99	#4 @ 10"	40.47	#4 @ 10"	39.47	#4 @ 10"	38.76	#4 @ 10"	38.24	#4 @ 10"	37.83	#4 @ 10"	37.50	#4 @ 10"	37.23	#4 @ 10"	37.02	#4 @ 10"	36.84	#4 @ 10"	36.68
	6	#4 @ 10"	43.97	#4 @ 10"	42.40	#4 @ 10"	41.36	#4 @ 10"	40.64	#4 @ 10"	40.10	#4 @ 10"	39.68	#4 @ 10"	39.35	#4 @ 10"	39.07	#4 @ 9"	43.33	#5 @ 10"	43.13	#5 @ 10"	42.96
	7	#4 @ 10"	46.19	#4 @ 10"	44.56	#4 @ 10"	43.49	#4 @ 10"	42.74	#4 @ 10"	42.18	#4 @ 10"	41.75	#4 @ 10"	41.41	#4 @ 10"	41.13	#4 @ 9"	45.65	#5 @ 10"	45.45	#5 @ 10"	45.28
7	2	#4 @ 10"	34.90	#4 @ 10"	33.44	#4 @ 10"	32.47	#4 @ 10"	31.78	#4 @ 10"	31.27	#4 @ 10"	30.86	#4 @ 10"	30.54	#4 @ 10"	30.27	#4 @ 10"	30.06	#4 @ 10"	29.88	#4 @ 10"	29.72
	3	#4 @ 10"	36.73	#4 @ 10"	35.23	#4 @ 10"	34.23	#4 @ 10"	33.53	#4 @ 10"	33.00	#4 @ 10"	32.59	#4 @ 10"	32.26	#4 @ 10"	31.99	#4 @ 10"	31.78	#4 @ 10"	31.59	#4 @ 10"	31.43
	4	#4 @ 10"	38.59	#4 @ 10"	37.04	#4 @ 10"	36.01	#4 @ 10"	35.29	#4 @ 10"	34.75	#4 @ 10"	34.33	#4 @ 10"	33.99	#4 @ 10"	33.71	#4 @ 10"	33.50	#4 @ 10"	33.31	#4 @ 10"	33.14
	5	#4 @ 10"	40.48	#4 @ 10"	38.86	#4 @ 10"	37.80	#4 @ 10"	37.06	#4 @ 10"	36.50	#4 @ 10"	36.07	#4 @ 10"	35.73	#4 @ 10"	35.44	#4 @ 10"	35.22	#4 @ 10"	35.03	#4 @ 10"	34.86
	6	#4 @ 10"	42.39	#4 @ 10"	40.71	#4 @ 10"	39.61	#4 @ 10"	38.84	#4 @ 10"	38.26	#4 @ 10"	37.82	#4 @ 10"	37.47	#4 @ 10"	37.17	#4 @ 10"	36.95	#4 @ 10"	36.75	#4 @ 10"	36.58

EXAMPLE:

SELECT THE c-BARS SIZE, SPACING AND STEEL QUANTITY FOR A 25.0 FEET LONG WINGWALL WITH m = 11.8 FT. AND k = 6.3 FT.

SOLUTION:

1. DETERMINE WINGWALL LENGTH IN MULTIPLE OF m:
   L / m = 25.0 / 11.8 = 2.12
   L = (2.12 x m), USE L ≤ (2.25 x m)
2. ROUND TO REAREST WHOLE NUMBER FOR m AND k:
   m = 11.8 FT., USE m = 12.0 FT.
   k = 6.3 FT., USE k = 6.0 FT.
3. DETERMINE c-BARS BY USING THE TABLE:
   L ≤ (2.25 x m)
   m = 12
   k = 6
   c-BARS: #6 @ 10"
   REINF. STEEL = 60.60 LB / LF
4. DETERMINE REINFORCING STEEL QUANTITY OF WHOLE WINGWALL:
   REINFORCING STEEL QUANTITY = 25.0 x 60.60 = 1,515 LB.



LIMITS OF CONCRETE SEALER AND WINGWALL DRAIN DETAILS

NOTES:
1. THE GEOCOMPOSITE SHALL BE SECURED TO THE WALL TO PREVENT MOVEMENT DURING BACKFILLING.
2. COST OF GEOCOMPOSITE DRAIN AND CONCRETE SEALER SHALL BE INCLUDED IN THE WORK.

Computer File Information			Sheet Revisions	
Creation Date: 07/04/12	Initials: HHB		Date:	Comments
Last Modification Date: 09/04/18	Initials:	R-X	09/04/18	LRFD Design
Full Path: www.codot.gov/business/designsupport		R-X		
Drawing File Name: 6010200202.dgn		R-X		
CAD Ver.: MicroStation V8 Scale: Not to Scale Units: English		R-X		

Colorado Department of Transportation
2829 West Howard Place
CDOT HQ, 3rd Floor
Denver, CO 80204
Phone: 303-757-9021 FAX: 303-757-9868
Division of Project Support HHB

WINGWALLS FOR PIPE OR BOX CULVERTS

Issued By: Project Development Branch July 4, 2012

STANDARD PLAN NO.
M-601-20
Sheet No. 2 of 2

Figure 4.10 - Reinforced Concrete Walls
CDOT Standard Plan No. M-601-20; 2 of 2

Cast-in-place concrete retaining walls should be used sparingly in the corridor, limited to urban context, where tied into other structures or infrastructure (eg, underpass or building), or where conditions make other wall types unfeasible. The typical format of cast-in-place concrete for slope retention is a cantilever-footer wall. Where used in conjunction with other structures or infrastructure, the concrete finish should match those elements in texture, color, and pattern. When used alone, the concrete is to have a standard gray finish, minimum of 1" chamfers along the front and back corners of the top of the wall, with wall tie scars patched to match the face of the wall. Cured concrete is to be protected from vandalism with an anti-graffiti coating.

Wall design should consider the aesthetic impact of the wall location and height. Where possible, provide clearance between the bottom of the wall and other infrastructure to allow for vegetation (3' minimum from shoulders or pavements). Walls taller than 4' should be terraced, with a 3' clear, level zone between walls for vegetation.

4.10 Handrails/Guard Rails

Guard rails are differentiated from standard fences in that a guard rail meets the fall protection guidance of the International Building Code and local jurisdictions for height and open-area criteria (typically 42” min height, with maximum openings in the barrier sized to prevent the passage of a 4” sphere). Guard rails are intended to provide a safety barrier between pedestrian/cyclist traffic and a safety hazard; guard rails may also be employed to create a barrier to exclude traffic from entering an environmentally sensitive or restricted area and when a typical fence may not be sufficient. Fences are covered in detail in Chapter 5 of this manual. Note: wildlife migration and passage should be carefully considered when determining the layout of and type of fence to be implemented. The use of guard rail-height fence and wire fabric should be limited to areas where this type of fence is necessary. See Colorado Parks and Wildlife “Fencing With Wildlife in Mind” for more information about wildlife friendly fencing (https://cpw.state.co.us/Documents/LandWater/PrivateLandPrograms/FencingWithWildlifeInMind.pdf).

The typical guard rail modifies the standard corridor fence in that post and rails are square, rough sawn material. The top rail should be set a minimum of 42” above adjacent grade, with three evenly-spaced rails. Maximum height of posts of 60” allows for use of an uncut, 8’ long post member.

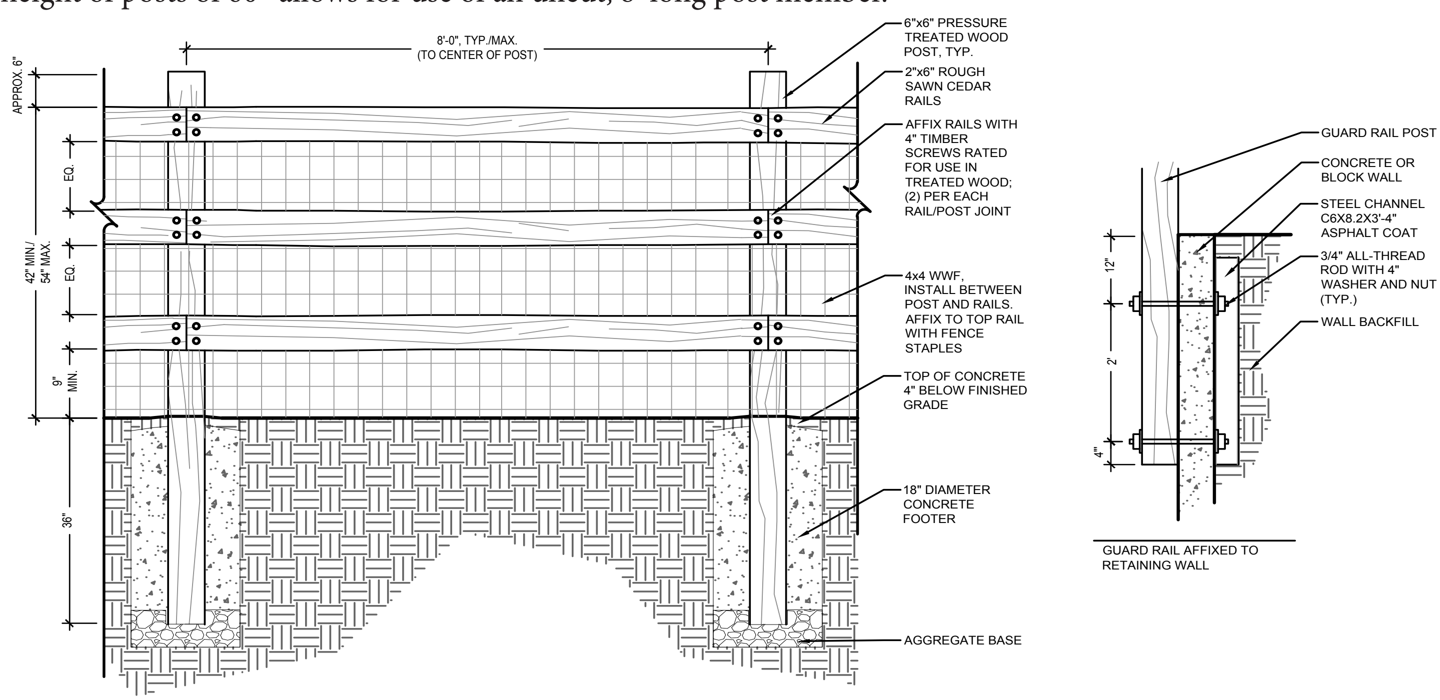


Figure 4.12 - Typical Wood Fence Guard Rail
Original detail by DHM Design.

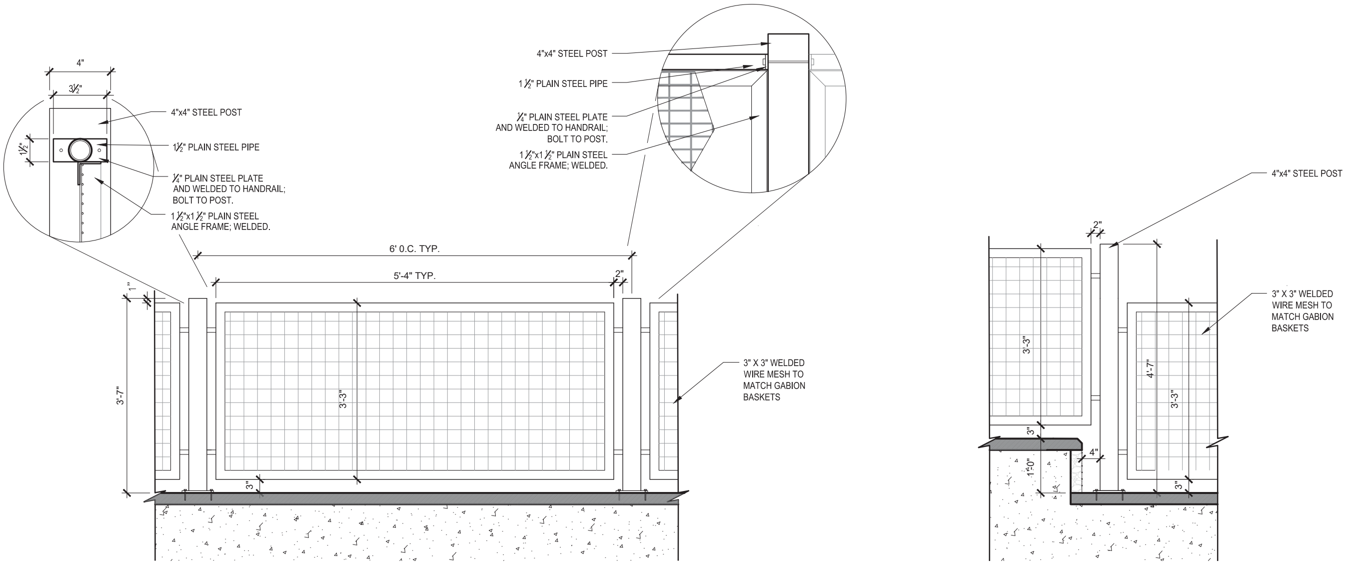


Figure 4.13 - Steel Guardrail
Original detail by DHM Design.

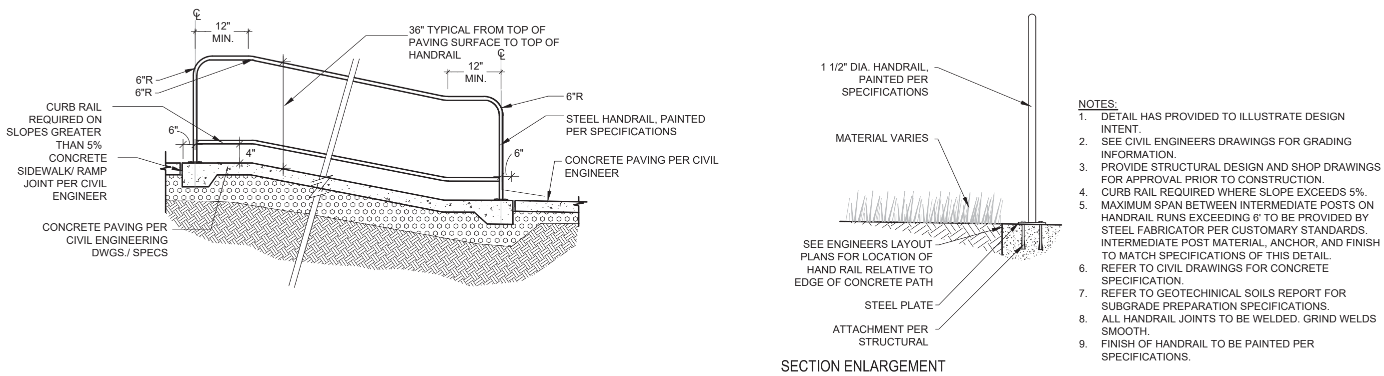


Figure 4.14 - Steel Handrail
Original detail by DHM Design.

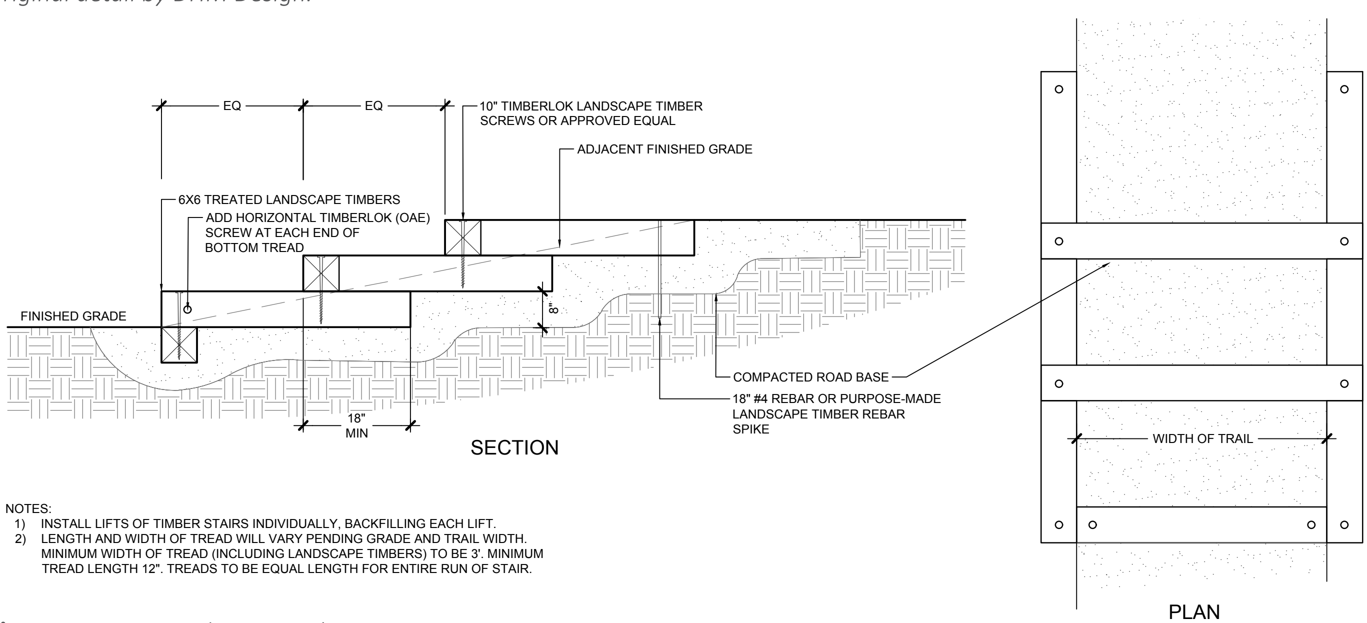
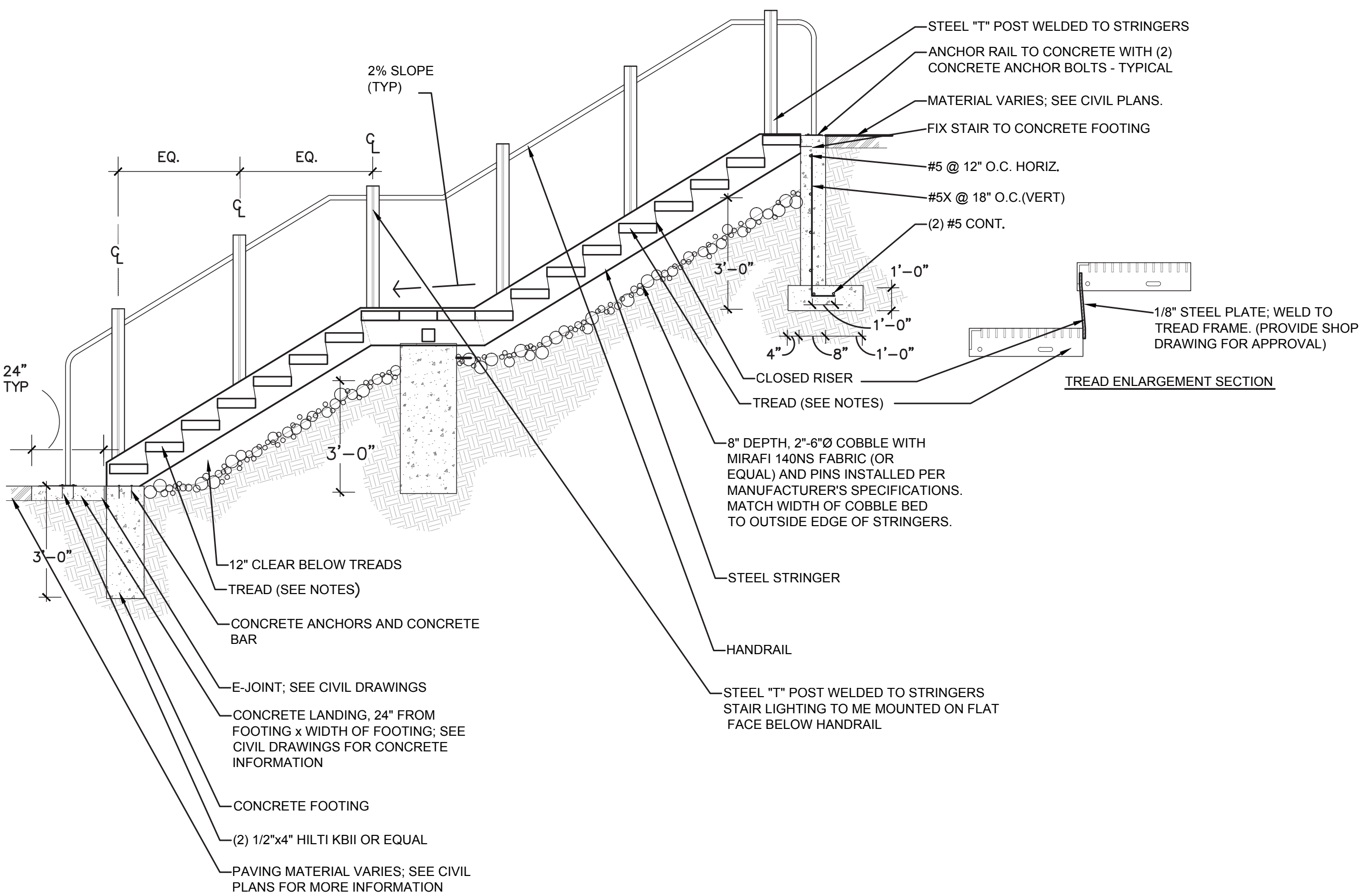
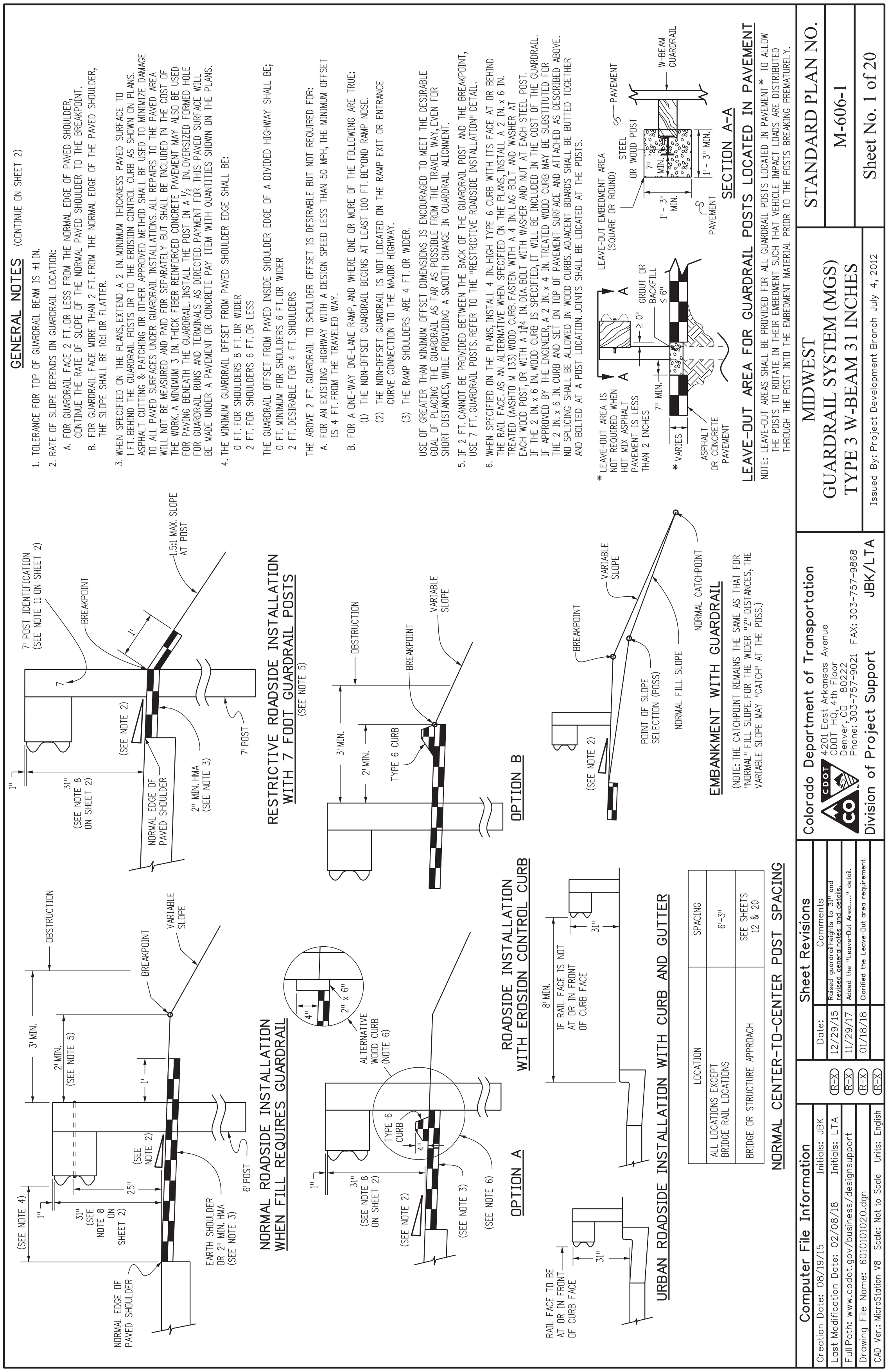


Figure 4.15 - Landscape Timber Stair
Original detail by DHM Design.



NOTES:
1) PROVIDE SHOP DRAWING FOR ENGINEER'S APPROVAL PRIOR TO CONSTRUCTION OF ANY STAIR.
2) TREAD TO BE STANDARD TYPE B TREAD BY MCNICHOLS COMPANY, OR APPROVED EQUAL.
-STEEL FINISH T.B.D.
-WELDED RECTANGULAR BAR GRATING WITH 1/2" CENTER-TO-CENTER SERRATIONS.
-CHECKERED PLATE NOSING.
-3/8" CLEAR MAX BAR SPACING PER CITY OF ASPEN.
-BEARING BAR DEPTH PER ENGINEERING LOAD AND SPAN CALCS.
-TREAD MEASURES 12-1/8"W X 3"D; LENGTH VARIES; SEE LAYOUT PLANS
3) PROVIDE POSITIVE DRAINAGE AT ALL SOLID TREADS AND LANDINGS.
4) STAIRWAY TO BE FABRICATED, ASSEMBLED, AND FINISHED IN THE SHOP. PROVIDE SHOP INSPECTIONS AS REQUIRED BY IBC.
5) ALL STAIR AND FOOTING DIMENSIONS TO BE DETERMINED BY A LICENSED STRUCTURAL ENGINEER.
6) GRIND ALL WELDS SMOOTH.
7) COBBLE TO BE CLEAN AND EVENLY GRADED. EXCAVATED COBBLE IS PERMITTED PROVIDED IT IS WASHED AND SORTED. CRUSHED ROCK IS NOT PERMITTED.
8) PROVIDE SHOP DRAWINGS TO OWNER'S REPRESENTATIVE PRIOR TO FABRICATION OF ANY PORTION OF THE STEEL STAIRS.
9) STEEL FINISH T.B.D.

Figure 4.16 - Steel Stair and Rail Detail
Original detail by DHM



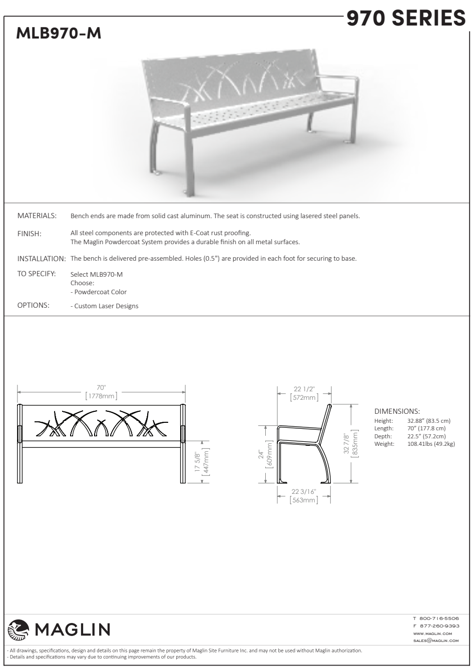
Note: This is sheet 1 in a series of 20. Reference the full sheet set for complete CDOT roadway guard rail details and standards.

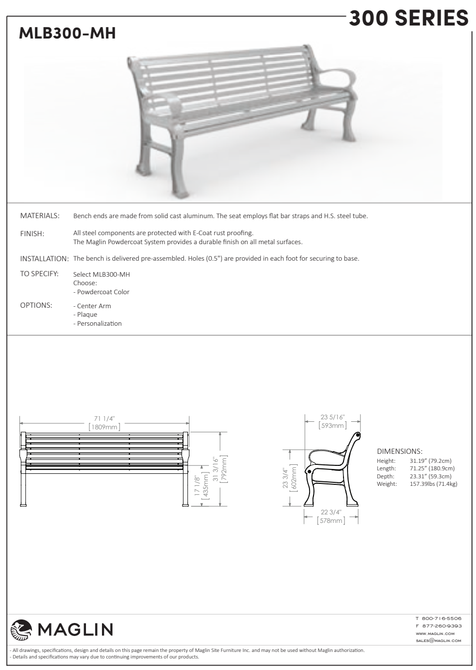
Figure 4.17 - Roadway Guardrail (W-Beam)
CDOT Standard Plan No M-606-1; 1 of 20

5 Miscellaneous Construction

This chapter includes furniture, amenities and service-related components found along the corridor. These elements are intended to be functional and durable, with a consistent and recognizable character throughout the corridor. These components are frequently used together at trailheads or other nodes along the trail. Trail nodes are often found at important community access points or within urban portions of the corridor. Consideration should be given to the context when specifying site furniture, amenities, and service structures. Alternate suppliers of all named products may be used with approval by RFTA.

5.1 Benches





Two bench models are shown. The MLB970-M model is the standard bench model for the corridor. The MLB300-MH model is an appropriate substitution for retrofit of site furntiure in settings with a traditional character. All benches are to be powder coated black, and are to be anchored to the ground surface per manufacturer's specifications.

Figure 5.1 - Bench Detail
Original detail by Maglin.

5.2 Trash Cans

Single ADA compliant chute-style (HA-CH)

Single ADA compliant latch-top (HA-P) (available in trash and recycling models)

Double ADA compliant chute-style (HA2-CH) (trash/recycling model shown)

Double ADA compliant latch-top (HA2-PX) (trash/recycling model shown)

Four wildlife-resistant models are shown. 'Chute-style' receptacles are consistant with existing models in the corridor and provide the easiest actuation of the access door for individuals who can not clasp and lift. 'Latch-top' models are consistent with the standard models used by several municipalities along the corridor.

Figure 5.2 - Trash Cans
Images from Bearsaver.com

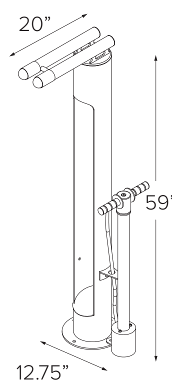
5.3 Dog Bag Dispenser

Figure 5.4 - Dog Bag Dispenser and Signage
Images from dogipot.com

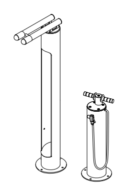
Typical dog bag dispenser pictured above; several makes and models are available. Standard dog bag rolls are 3"x3"x8 5/8"; dispensers are to be size to accommodate standard dog bag rolls. Dog bag dispensers are to be mounted to a 6" unpeeled cedar post, with standard RFTA regulation/etiquitte sign affixed above, as shown.

5.4 Bike Fix-it Station

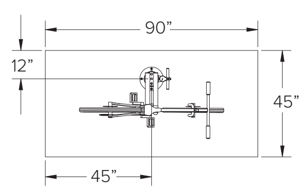
Bike station to be "Fixit" by Dero or approved equal. Finish is to be powder coat orange.



Fixit with Air Kit 2



Fixit with Air Kit 3



Minimum Footprint

CAPACITY
1 Bike

MATERIALS
Main body: 6"x .154" tube
Bike Hanger: 1.5" sch. 40 pipe, ¼" plate
Foot: 10" dia. x .25" plate
Tool tethers: 5/32" stainless steel cable
Manual air pump
Hand tools:
- Philips and flat head screwdrivers
- 2.5, 3, 4, 5, 6, 8mm Allen wrenches
- Headset wrench
- Pedal wrench
- 8, 9, 10, 11mm box wrenches
- Tire levers (2)

FINISHES

☐ **Galvanized**
An after fabrication hot dipped galvanized finish is our standard option.

☐ **Powder Coat**
Our powder coat finish assures a high level of adhesion and durability by following these steps:
1. Sandblast
2. Epoxy primer electrostatically applied
3. Final thick TGIC polyester powder coat

☐ **Thermoplastic**
In addition to an increased thickness (8-10mils), the thermoplastic finish covers a galvanized layer and offers superior impact resistance over powder coating.

☐ **Stainless**
Stainless Steel: 304 grade stainless steel material finished in either a high polished shine or a satin finish.

MOUNT OPTIONS

☐ **In-ground**
Is embedded into concrete base.

☐ **Surface**
Has 10" diameter x.25" foot with four anchors per foot.

Figure 5.3 - "Fixit" Bike Service Station
Original detail by Dero.

5.5 Cigarette Urns

Cigaretter urns may be appropriate at trailheads accessible by vehicle and in proximity to shade structures, but are not necessary at locations accessed only via the trail corridor. Urns are to be permanently affixed to the gound using expansion anchors (for pavement) or soil anchors (for bare ground or class 6 ABC).

Infinity Base Mount Smoking Receptacle

Item #: T9AB55694

Figure 5.5 - Outdoor Cigarette Urn.
Photos from www.globalindustrial.com

5.6 Removable Bollards

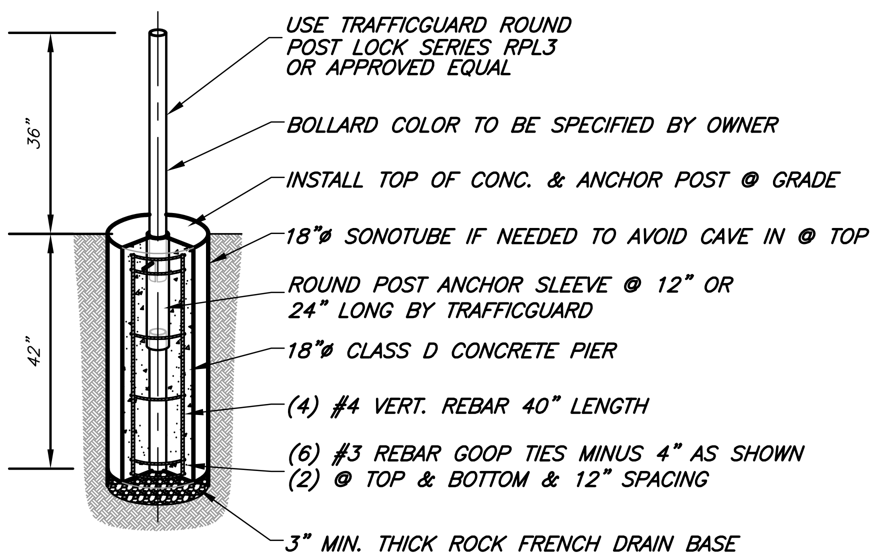


Figure 5.6 - Removable Bollard.
Detail provided by RFTA. Original detail by SGM, Inc.

5.7 Shade Structures

The following three pages illustrate the shade structures installed in three locations in the corridor as of the time of writing of this document. Modifications to the shelter design may be required to respond to materials availability (specifically, the reclaimed rails) and structural requirements. Original design and detailing of shelter by Land+Shelter Architecture and Planning.

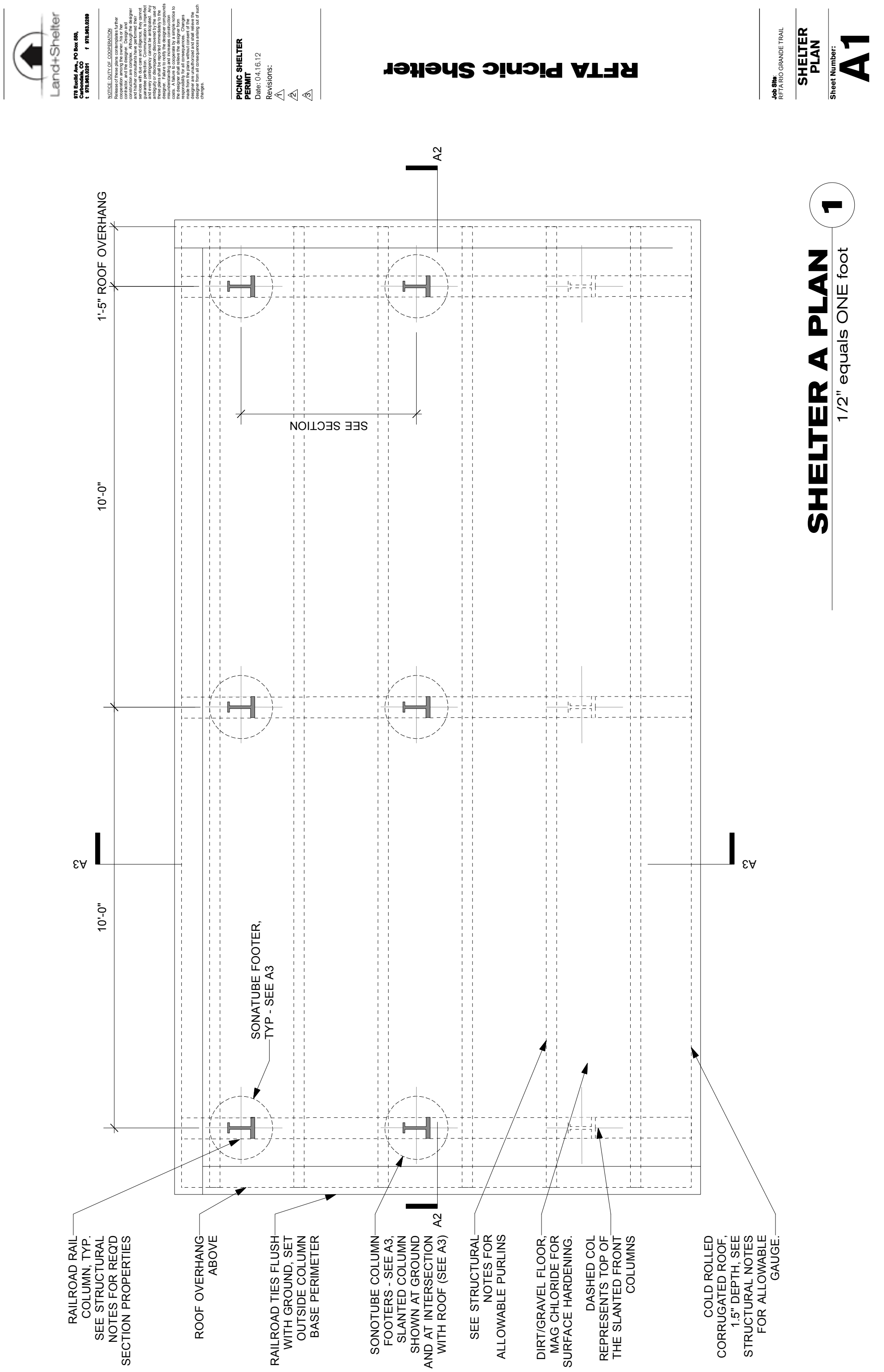


Figure 5.7 - Shade Structure Detail
Original detail by Land+Shelter.

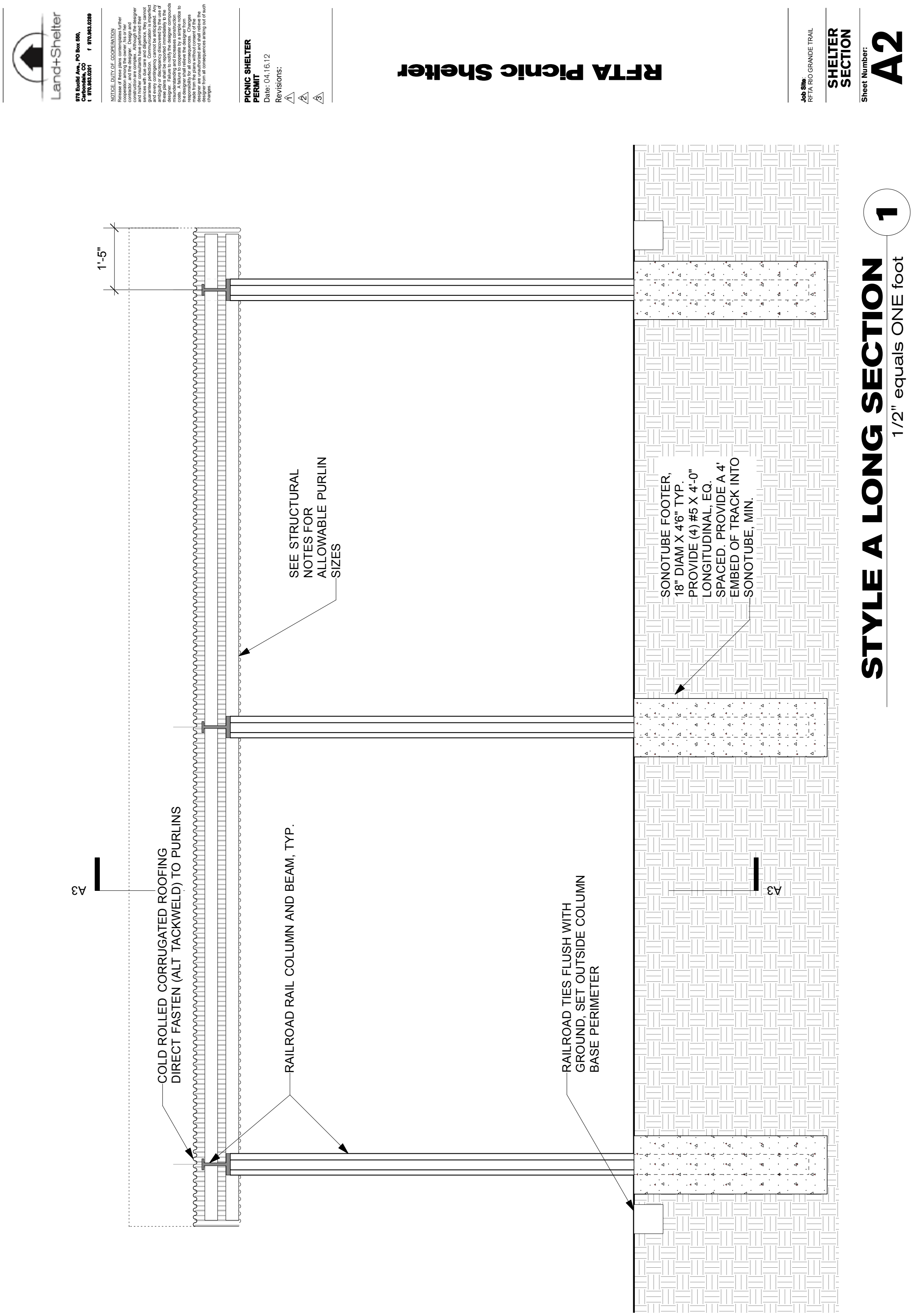


Figure 5.8 - Shade Structure Detail
Original detail by Land+Shelter.

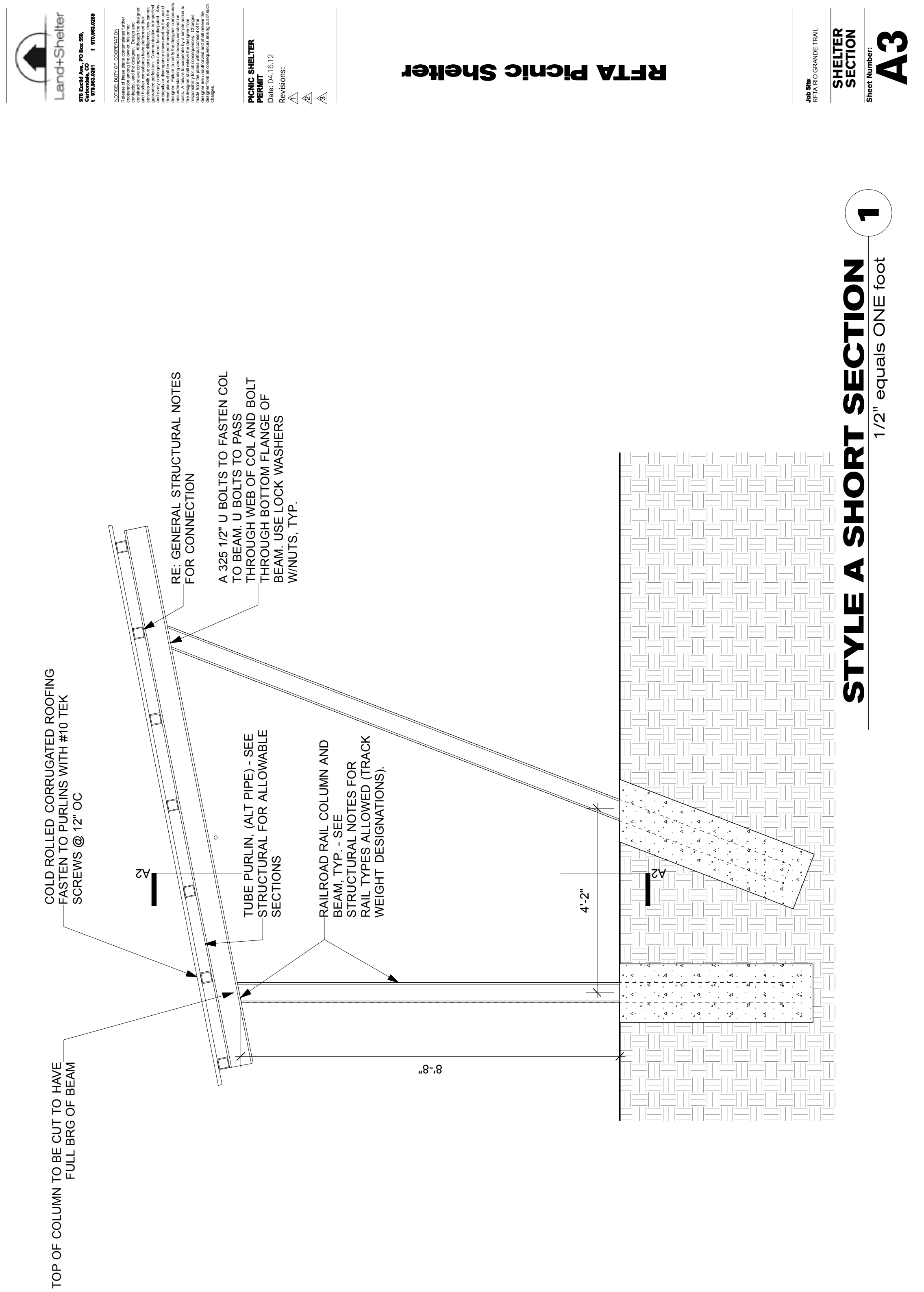


Figure 5.9 - Shade Structure Detail
Original detail by Land+Shelter.

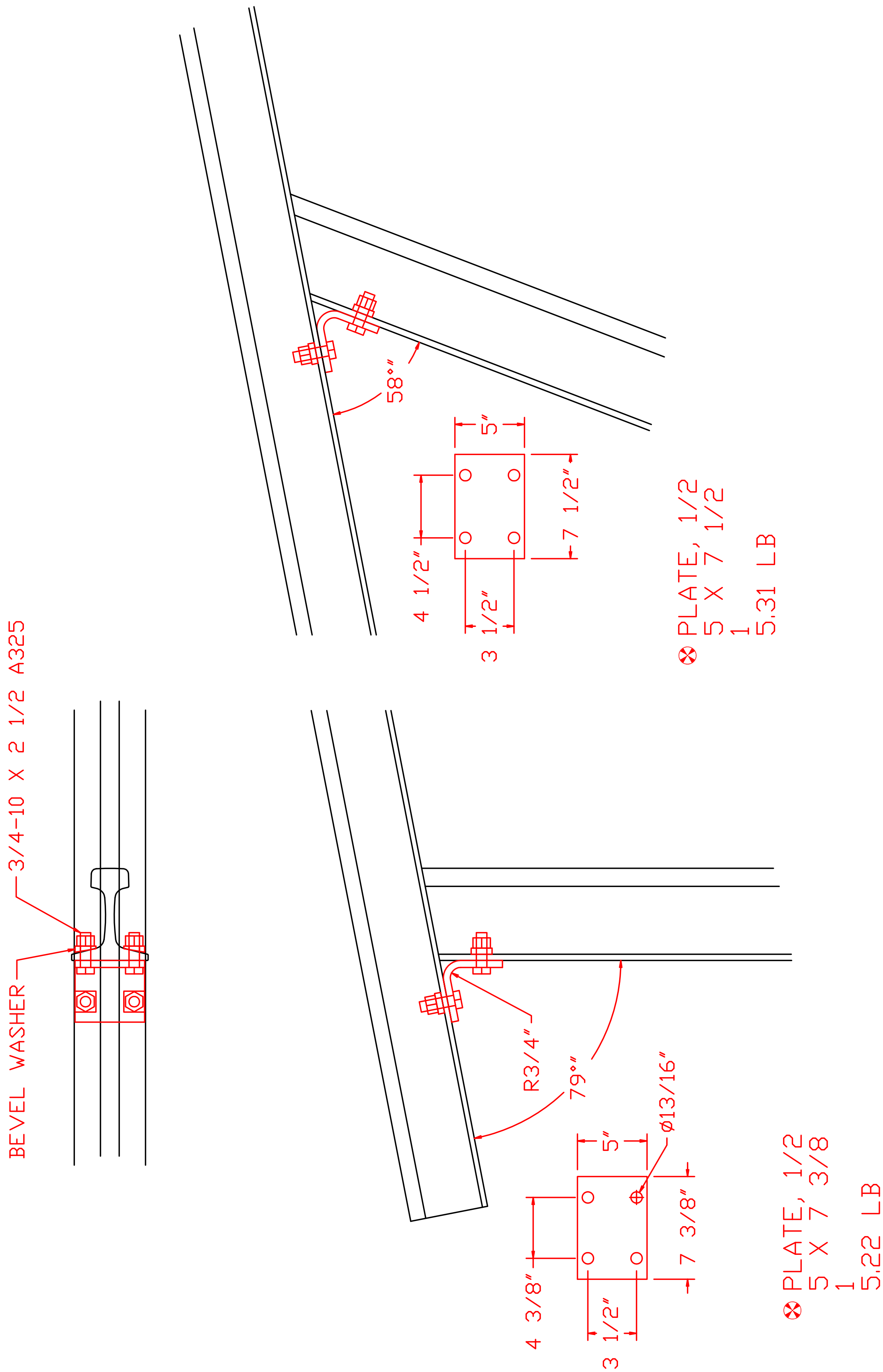


Figure 5.10 - Shade Structure Post-to-Beam Connection
Detail provided by RFTA.

5.8 Fencing

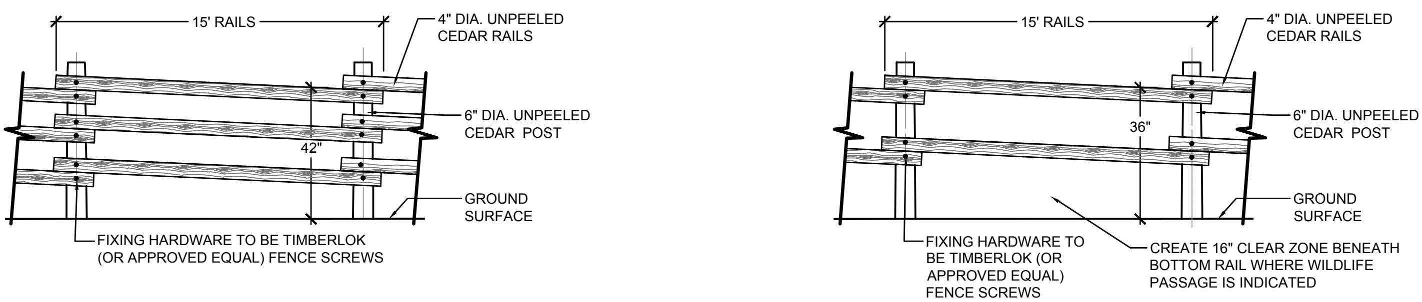


Figure 5.11 - Typical Wood Fence Detail
Original detail by DHM Design.

Note: Both Round Rail and Split Rail wood fences are found in the corridor. The Split Rail detail is the standard detail for transit stops. The two-rail Round Rail is found along the trail corridor and is used for general boundary identification and access control. This fence format is appropriate for zones where wildlife passage is important, boundary identification is necessary, but hazards (such as a fall exceeding 30") are not present. The two-rail fence may also be used to signal the approach to a trailhead, trail node, or intersection. Where access control or boundary delineation indicate a more robust fence, (e.g. along seasonal closures) the three-rail fence may be employed. For any area requiring fall protection, refer to "Handrails/Guard Rails" in Chapter 4.

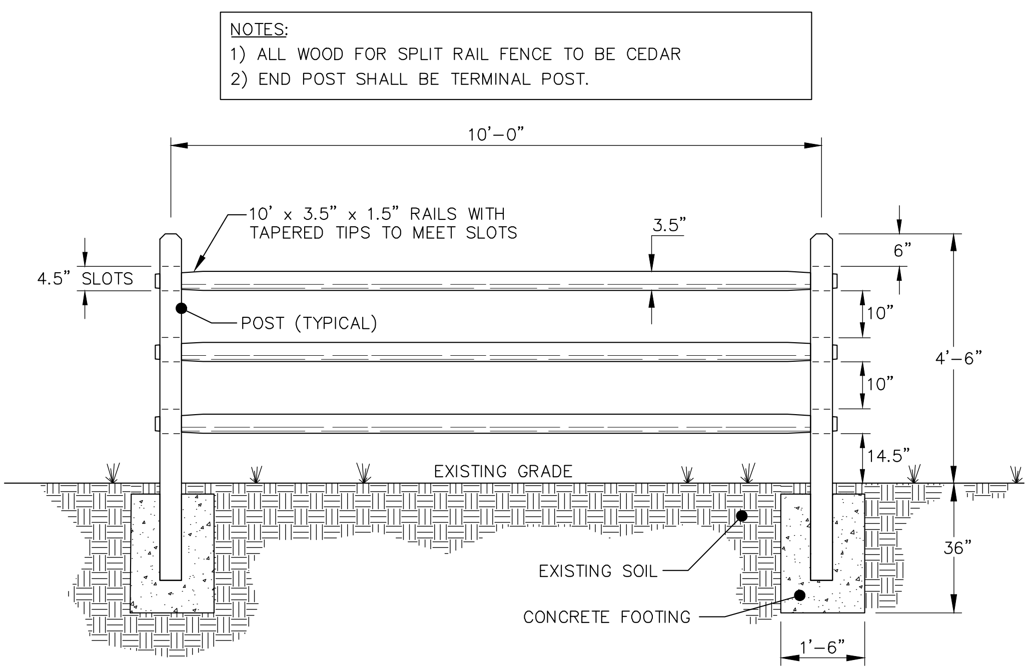


Figure 5.12 - Cedar Split Rail Fence Detail
Original detail by DHM.

5.9 Restroom/Vault Locations

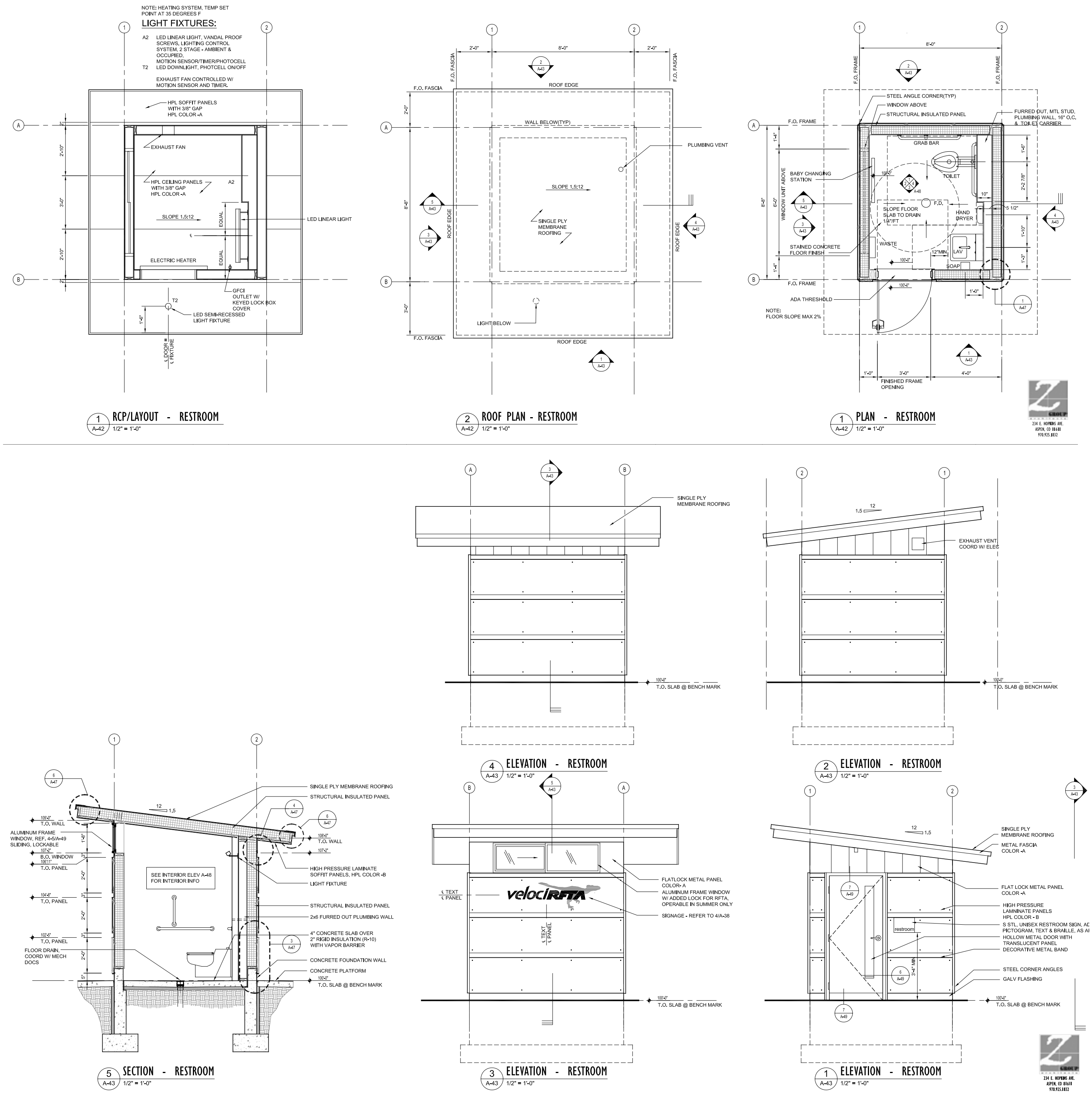


Figure 5.13 - Single Custom Restroom Detail
Original detail by Baker. Provided by RFTA

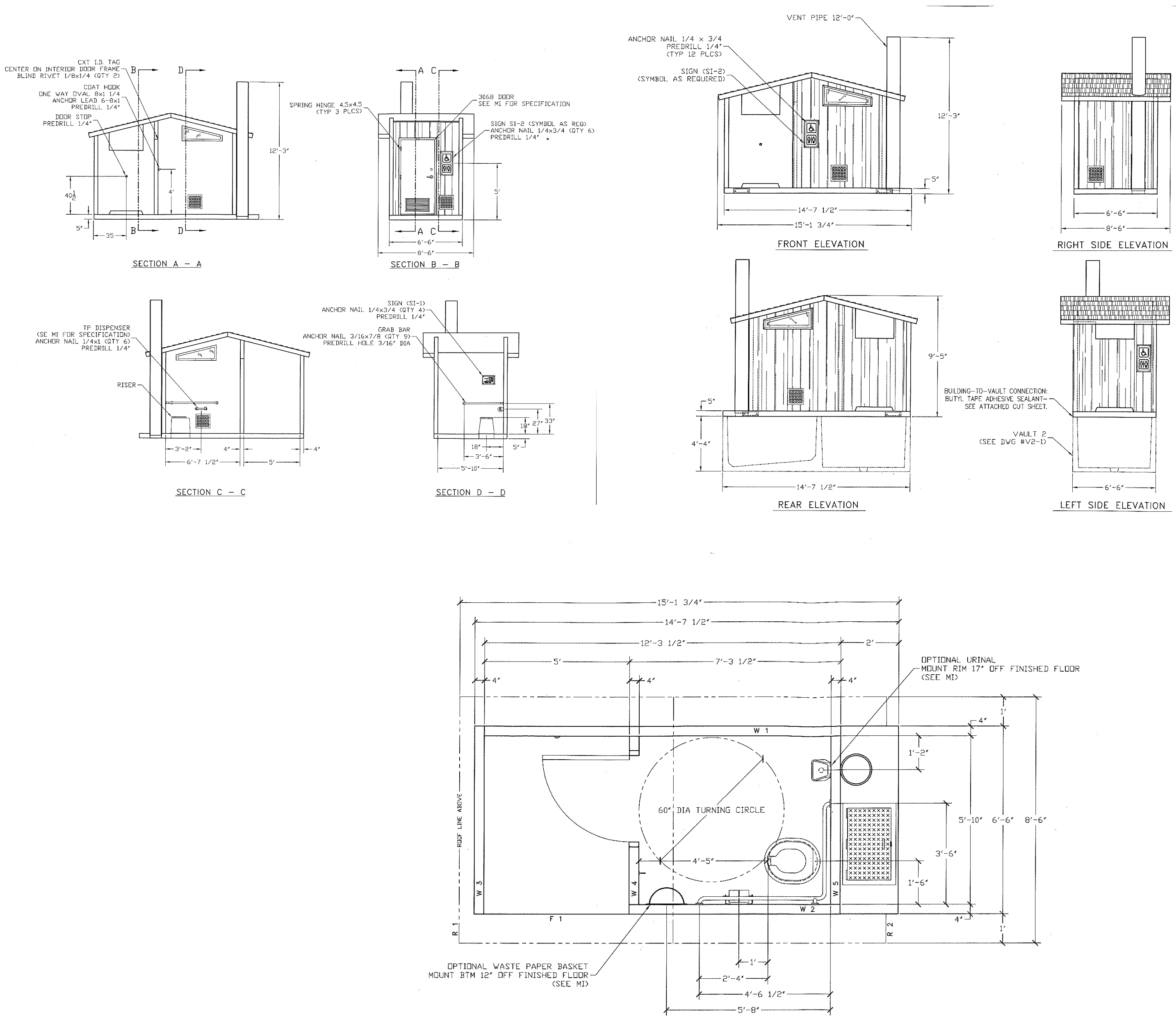


Figure 5.14 - Single Precast Restroom
Original detail by Precast Products.
Provided by RFTA

6 Traffic Control/ Methods of Handling Traffic

Signage and striping for the corridor should comply with tthe current AASHTO Guide to Bicycle Facilities, 4th Edition-2012 (AASHTO-GBF), and the current Manual on Uniform Traffic Control Devices (MUTCD). Chapter 5.4, Pavement Markings, Signs, and Signals from the AASHTO-GBF is excerpted here for reference, followed by a selection of regulatory signs from the MUTCD.

5.4 PAVEMENT MARKINGS, SIGNS, AND SIGNALS

The MUTCD (*7*) regulates the design and use of all traffic control devices. Part 9 of the MUTCD presents standards and guidance for the design and use of signs, pavement markings, and signals that may be used to regulate, warn, and guide bicyclists on roadways and pathways. Other parts of the MUTCD also include information relevant to shared use path operation and should be consulted as needed. Path users should never be given conflicting traffic control messages (e.g., use of a "STOP" sign at a signalized intersection), leaving it unclear as to which device should be followed.

5.4.1 Pavement Markings

Pavement markings can provide important guidance and information for path and roadway users. Pavement markings should be retroreflective. They should not be slippery or rise more than 0.16 in. (4 mm) above the pavement.

Marked Crosswalks

Marked crosswalks are recommended at intersections between shared use paths and roadways. They delineate the crossing location and can help alert roadway users to the potential conflict ahead. At a mid-block location, no legally recognized crosswalk for pedestrians is present if no crosswalk is marked. As noted in Section 5.3.2 some states extend the rights and responsibilities of pedestrians at crosswalks to bicyclists, while other states do not; therefore, it is important for designers to understand the laws within their state regarding assignment of right of way for pedestrians and bicyclists (and other path users).

Where crosswalks are marked at shared use path crossings, the use of high visibility (i.e., ladder or zebra) markings is recommended as these are more visible to approaching roadway users. More information on the installation of crosswalks at path–roadway intersections is provided in Section 5.3.2.

Centerline Striping

A 4 to 6 in. (100 to 150 mm) wide, yellow centerline stripe may be used to separate opposite directions of travel where passing is inadvisable. This stripe should be dotted where there is adequate passing sight distance, and solid in locations where passing by path users should be discouraged. This may be particularly beneficial in the following circumstances: (1) for pathways with heavy user volumes; (2) on curves with restricted sight distance, or design speeds less than 14 mph (24 km/h); and (3) on unlit paths where night-time riding is not prohibited. The use of the broken centerline stripe may not be appropriate in parks or natural settings. However, on paths where a centerline is not provided along the entire length of the path, appropriate locations for a solid centerline stripe should still be considered where described above.

A solid yellow centerline stripe may be used on the approach to intersections to discourage passing on the approach and departure of an intersection. If used, the centerline should be striped solid up to the stopping sight distance from edge of sidewalk (or roadway, if no sidewalk is present). A consistent approach to intersection striping can help to increase awareness of intersections.

5-50

Figure 6.1 - AASHTO-GBF page 5-50
Original content by AASHTO.

Approach Markings for Obstructions

Obstructions should not be located in the clear width of a path. Where an obstruction on the traveled portion occurs (for example, in situations where bollards are used), channelizing lines of appropriate color (yellow for centerline, otherwise white) should be used to guide path users around it. An example of a centerline treatment is given in Figure 5-21. For obstructions located on the edge of the path, an obstruction marking (see Figure 4-30) should be used. Approach markings should be tapered from the approach end of the obstruction to a point at least 1 ft (0.3 m) from the obstruction (See Table 4-1 to determine taper length).

Pavement Markings to Supplement Intersection Control

Stop and yield lines may be used to indicate the point at which a path user should stop or yield at a traffic control device. Design of stop and yield lines is described in Chapter 3B of the MUTCD (*7*). Stop or yield lines may be placed across the entire width of the path. If used, the stop or yield line should be placed a minimum of 2 ft (0.6 m) behind the nearest sidewalk or edge of roadway if a sidewalk is not present.

Supplemental Pavement Markings on Approaches

Advance pavement markings may be used on roadway or path approaches at crossings where the crossing is unexpected or where there is a history of crashes, conflicts, or complaints. If a supplemental word marking (such as "HWY XING") is used, its leading edge should be located at or near the point where the approaching user passes the intersection warning sign or advance traffic control warning sign that the marking supplements. Additional markings may be placed closer to the crossing if needed, but should be at least 50 ft (15 m) from the crossing. Advance pavement markings may be placed across the entire width of the path or within the approach lane. Pavement markings should not replace the appropriate signs. Pavement markings may be words or symbols as described in Part 3 of the MUTCD (*7*).

Advance Stop or Yield Lines

Advance stop lines or yield lines may be used on multilane roadway approaches to a path crossing where the path is given priority. The applicability of either a stop line or a yield line is governed by state law. Figure 5-23 shows an application of advanced yield lines, and Figures 5-18 and 5-20 illustrate the use of both applications where the path is given priority. Advance stop and yield lines reduce the likelihood for a multiple-threat crash between the path user and a vehicle. The advance stop or yield line provides a clearer field of vision between path users who are crossing the road and approaching vehicles in both lanes. These treatments have shown promising results (*16*), (*17*).

Figure 6.2 - AASHTO-GBF page 5-51
Original content by AASHTO.

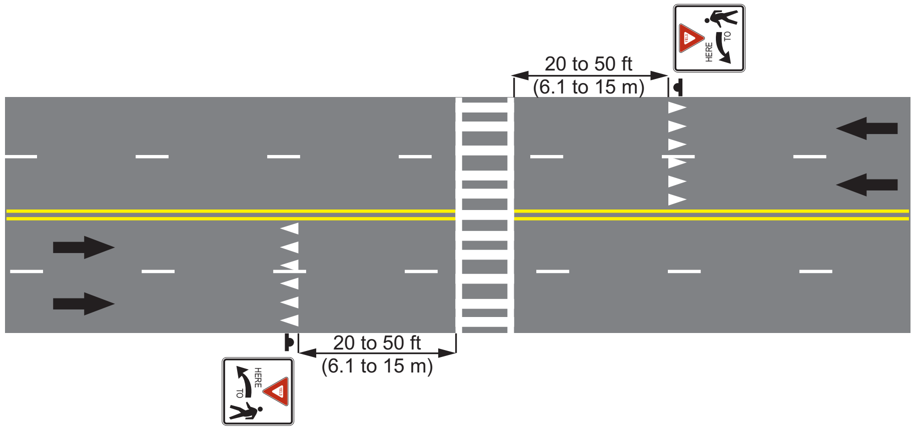


Figure 5-23. Advance Yield Signs and Markings

5.4.2 Signs

All signs should be retroreflective and conform to the color, legend, and shape requirements described in the MUTCD. (*7*) Signs used along a path may be reduced in size per Table 9B-1 of the MUTCD. Signs utilized along a roadway which are visible to motorists should not be reduced in size and should conform to the sizes established in the MUTCD.

Regulatory signs notify pathway (and roadway) users of location-specific regulations. Such a sign is installed at or near the location where the regulation applies. Regulatory signs are generally rectangular with white backgrounds and black text and symbols.

Warning signs are utilized to notify road and pathway users of unexpected conditions that might need a reduction of speed or other action. A warning sign should be used, for example, where pathway width is reduced in a short section because of a constraint. However, warning signs should be used sparingly; use perceived as excessive or unnecessary can result in disrespect for other important signs.

Warning signs are diamond shaped with black symbols and text. Permanent warning signs for bicycle facilities should be yellow or fluorescent yellow-green (temporary warning signs should be orange). In general, a uniform application of warning signs of the same color should be used.

For advance warning sign placements on shared use paths, the sign should be placed to allow adequate perception-response time. The location of the sign should be based on the stopping sight distance needed by the fastest expected path user; however, in no instance should the sign be located closer than 100 ft (30 m) from the location warranting the advance warning. Warning signs should not be placed too far in advance of the condition, such that path users tend to forget the warning because of other distractions.

The purpose of guide and wayfinding signs is to inform path users of intersecting routes, direct them to important destinations, and generally to give information that will help them along their way in the most simple and direct manner. Guide signs are rectangular with green backgrounds and white text.

Figure 6.3 - AASHTO-GBF page 5-52
Original content by AASHTO.

Shared Use Path Crossing Warning Sign Assembly

Roadway users may be warned of a shared use path crossing by utilizing a combined bicycle-pedestrian warning sign (W11-15), as shown in Figure 5-24, or a bicycle warning sign (W11-1). On a roadway approach to a path crossing, placement of an intersection or advance traffic control warning sign should be at (or close to) the distance recommended for the approach speed in Table 2C-4 of the MUTCD (*7*). See Figures 5-17 through 5-20.

The assembly consists of a W11-15 or a W11-1 accompanied by a W16-7p (downward arrow) plaque mounted below the warning sign. This sign should not be installed at the crossing if the roadway traffic is yield-, stop-, or signal-controlled. The W16-8P (path name) plaque may be mounted on the sign assembly (below the W11-15 or W11-1 sign) to notify approaching roadway users of the name of the shared use path being crossed.

At path crossings that experience frequent conflicts between motorists and path users, or on multilane roadways where a sign on the right-hand side of the roadway may not be visible to all travel lanes, an additional path crossing warning sign assembly should be installed on the opposite side of the road, or on the refuge island, if there is one.

Figure 5-24. Advance Warning Assembly Example

The combined bicycle-pedestrian warning sign (W11-15) or bicycle warning sign (W11-1) may be used in advance of shared use path crossings of roadways. Again, this warning sign should not be used in advance of locations where the roadway is stop-, yield-, or signal-controlled. Advance warning sign assemblies may be supplemented with a W16-9p (AHEAD) plaque or W16-2P (XX FEET) plaque located below the W11-15P sign.

Traffic Control Regulatory Signs

"YIELD" and "STOP" signs are used to assign priority at controlled but unsignalized path–roadway intersections. The choice of traffic control (if any) should be made with reference to the priority assignment guidance provided in Section 5.3.2 and in the MUTCD. The design and use of the signs is described in sections 2B and 9B of the MUTCD (*7*).

Intersection and Advance Traffic Control Warning Signs

Advance traffic control warning signs announce the presence of a traffic control of the indicated type ("YIELD," "STOP," or signal) where the control itself is not visible for a sufficient distance on an approach for users to respond to the device. An intersection warning sign may be used in advance of an intersection to indicate the presence of the intersection and the possibility of turning or entering traffic.

On a shared use path approach, placement of an advance warning sign should be at a distance at least as great as the stopping sight distance of the fastest expected path user in advance of the location to which the sign applies. In no case should the advance placement distance be less than 50 ft (15 m). See Figures 5-17 through 5-20.

Figure 6.4 - AASHTO-GBF page 5-53
Original content by AASHTO.

An intersection or advance traffic control warning sign may carry a W16-8P (road or path name) plaque to identify the intersecting road or path, as appropriate for the approach. An advisory speed (W13-1) plaque may be added to the bottom of the sign assembly to advise the approaching user to the proper traveling speed for the available sight lines or geometric conditions.

Guide Signs

Road name/path name signs (D3-1 and W16-8P) should be placed at all path–roadway crossings. This helps path users track their locations. At mid-block crossings, the D3-1 sign may be installed on the same post with a regulatory sign.

Guide signs to indicate directions, destinations, distances, route numbers, and names of crossing streets should be used in the same manner as on roadways and as described in Section 4.11.

Reference location signs (also called mile markers) assist path users in estimating their progress, provide a means for identifying the location of emergency incidents, and are beneficial during maintenance activities. Section 9B.24 of the MUTCD provides guidance for the use of reference location signs.

Where used, wayfinding signs for shared use paths should be implemented according to the principles discussed in Section 4.11. Mode-specific guide signs (D11-1a, D11-2, D11-3, and D11-4) may be used to guide different types of users to the traveled way that is intended for their respective modes (see Figure 5-25). If used, the signs should be installed at the point where the separate pathways diverge (see Section 9B.25 of the MUTCD) (*7*).

Figure 5-25. Mode-Specific Guide Signs

5.4.3 Signalized and Active Warning Crossings

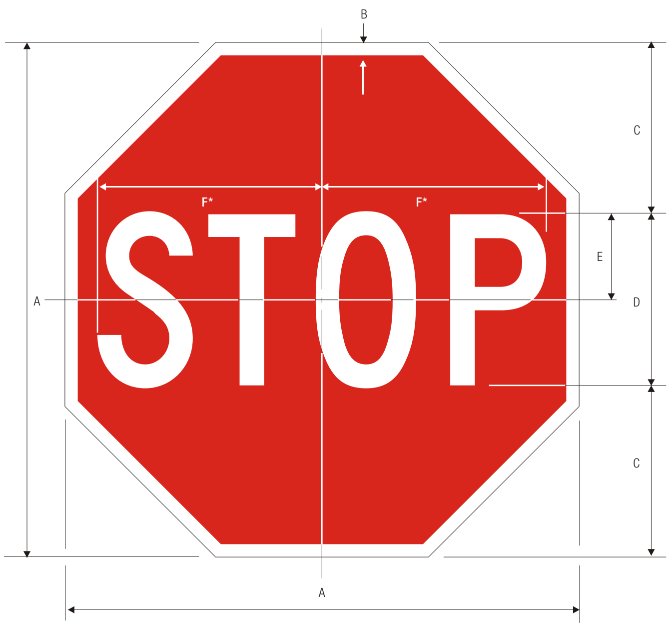
As discussed earlier in this chapter, it may be appropriate to provide active warning or a traffic signal at some shared use path crossings of roadways. Guidance on the need for a signal and other traffic control devices is provided in the MUTCD (*7*) and in other sources such as FHWA's *Safety Effects of Marked Versus Unmarked Crosswalks at Uncontrolled Locations: Final Report and Recommended Guidelines* (*18*). Path user volumes may be used to determine the need for a signal and/or other active warning devices, and in some situations when considering path user volume, it may be appropriate to assess whether the path users have access to another appropriate crossing location.

Figure 6.5 - AASHTO-GBF page 5-54

Original content by AASHTO.

6.1 Standard Regulatory Signage

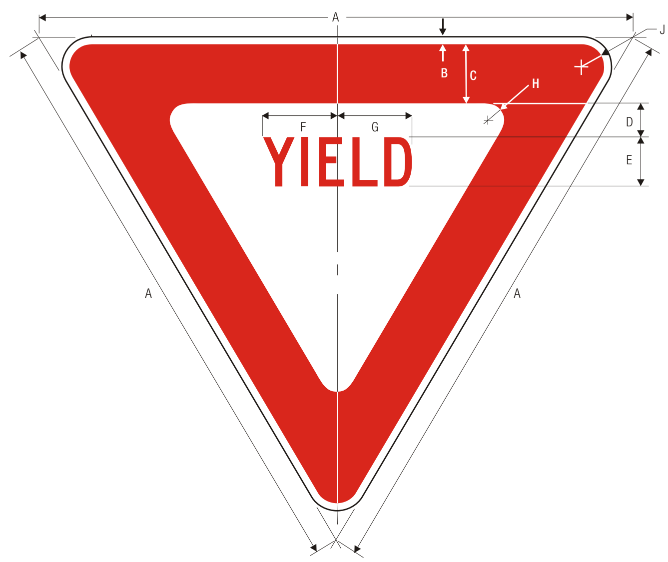
Following is a selection of MUTCD standard signs that are commonly related to trails. Additional signage that is not depicted may be necessary; reference the MUTCD for individual circumstances. Placement of signs is to be as described in this manual, as required by local jurisdictions or ROW holders, and as defined by the project engineer for specific project work.



R1-1
STOP

*Reduce spacing 40%

	A	B	C	D	E	F
	18	.375	6	6 C	3	7.75
	24	.625	8	8 C	4	10
C	30	.75	10	10 C	5	12.5
	36	.875	12	12 C	6	15
	48	1.25	16	16 C	8	20

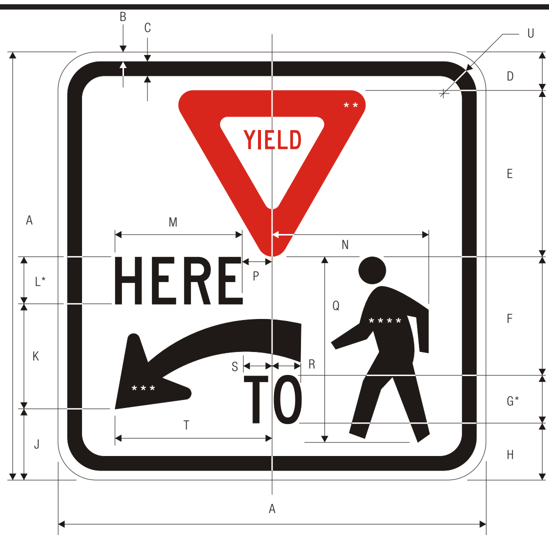


R1-2
YIELD

	A	B	C	D	E	F	G	H	J
	18	.375	2	1	1.5 C	2.375	2.188	.625	1.5
	24	.375	3	1.375	2 C	3.25	3	.875	1.5
	30	.625	4	1.75	2.5 C	3.938	3.625	.875	1.5
C	36	.75	5	2	3 C	4.688	4.375	1.25	2
	48	1	6	2.75	4 C	6.25	5.875	2	3
	60	1.5	8	3.5	5 C	7.875	7.25	2.5	4

Figure 6.6 - Common Trail Signs 1

Original content by MUTCD.

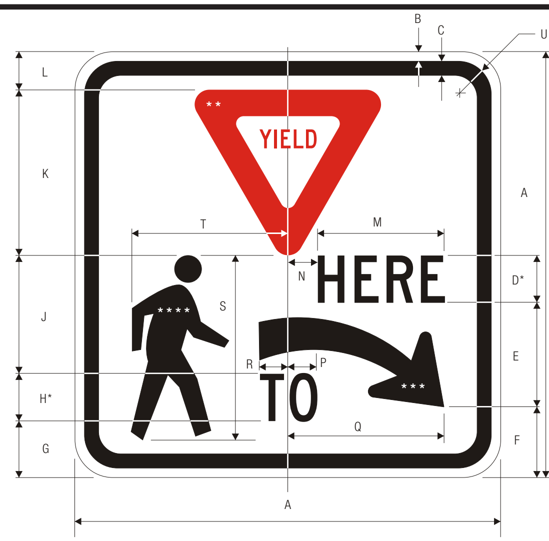


R1-5L
YIELD HERE TO PEDESTRIANS

	A	B	C	D	E	F	G	H	J	K	L
C	18	.375	.625	1.625	7	5	2 C	2.375	3	4.375	2 C
	30	.5	.75	2.75	11.5	8.5	3 C	4.25	5	7.25	3 C
	36	.625	.875	3.25	14	10	4 C	4.75	6	8.75	4 C

M	N	P	Q	R	S	T	U
5.364	6.605	1.240	7.805	1.220	1.220	6.605	1.5
8.061	11	2	13	1.820	1.820	11	1.875
10.728	13.21	2.48	15.61	2.44	2.44	13.21	2.25

*Series 2000 Standard Alphabets.
**Insert R1-2 and size to fit.
***Insert R10-6a Arrow and size to fit.
****See 6-10 for design detail.



R1-5R
YIELD HERE TO PEDESTRIANS

	A	B	C	D	E	F	G	H	J	K	L
C	18	.375	.625	2 C	4.375	3	2.375	2 C	5	7	1.625
	30	.5	.75	3 C	7.25	5	4.25	3 C	8.5	11.5	2.75
	36	.625	.875	4 C	8.75	6	4.75	4 C	10	14	3.25

M	N	P	Q	R	S	T	U
5.364	1.240	1.220	6.605	1.220	7.805	6.605	1.5
8.061	2	1.820	11	1.820	13	11	1.875
10.728	2.48	2.44	13.21	2.44	15.61	13.21	2.25

*Series 2000 Standard Alphabets.
**Insert R1-2 and size to fit.
***Insert R10-6a Arrow and size to fit.
****See 6-10 for design detail.

R1-5aL
YIELD HERE TO PEDESTRIANS

	A	B	C	D	E	F	G	H	J	K	L
C	18	24	.375	.625	2	8	.75	2 C	3.625	1.250	2.375
	30	42	.5	.75	5	13.5	1.25	3 C	6	2	5.25
	36	48	.625	.875	4	16	1.5	4 C	7.25	2.5	4.75

M	N	P	Q	R	S	T	U
5.364	1.761	5.604	2.427	2.401	7.125	6	1.5
8.059	2.622	9.375	3.641	4.359	10.681	10	1.875
10.744	3.522	11.208	4.853	4.802	14.236	12	2.25

*Series 2000 Standard Alphabets.
**Insert R1-2 and size to fit.
***Insert R10-6a Arrow and size to fit.

R1-5aR
YIELD HERE TO PEDESTRIANS

	A	B	C	D	E	F	G	H	J	K	L
C	18	24	.375	.625	6	2.375	2 C	1.250	3.625	.75	8
	30	42	.5	.75	10	5.25	3 C	2	6	1.25	13.5
	36	48	.625	.875	12	4.75	4 C	2.5	7.25	1.5	16

M	N	P	Q	R	S	T	U
2	5.364	1.761	5.604	7.125	2.401	2.427	1.5
5	8.059	2.622	9.375	10.681	4.359	3.641	1.875
4	10.744	3.522	11.208	14.236	4.802	4.853	2.25

*Series 2000 Standard Alphabets.
**Insert R1-2 and size to fit.
***Insert R10-6a Arrow and reduce to fit.

Figure 6.7 - Common Trail Signs 2

Figure 6.7 - Common Trail Signs 2

Original content by MUTCD.

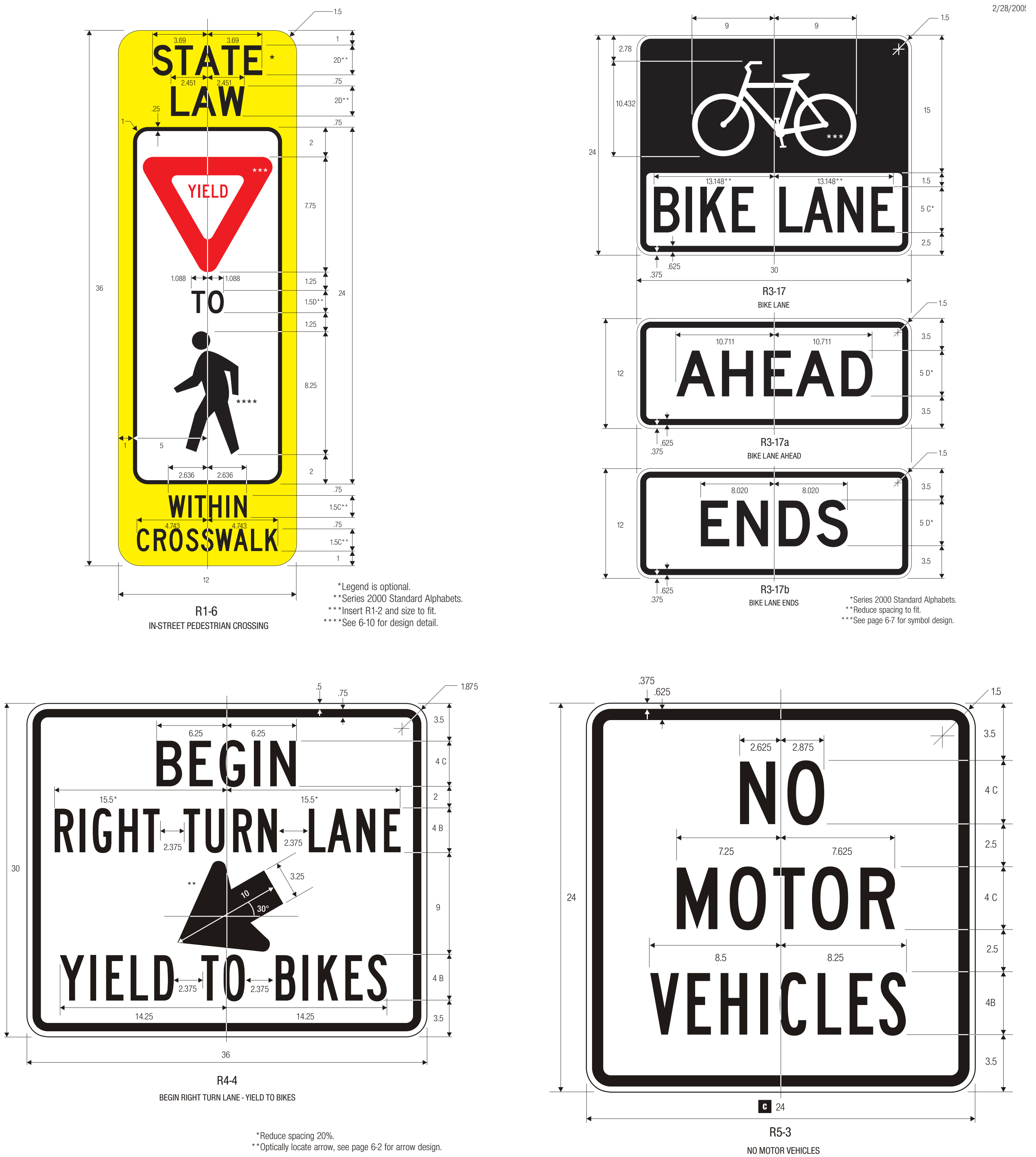
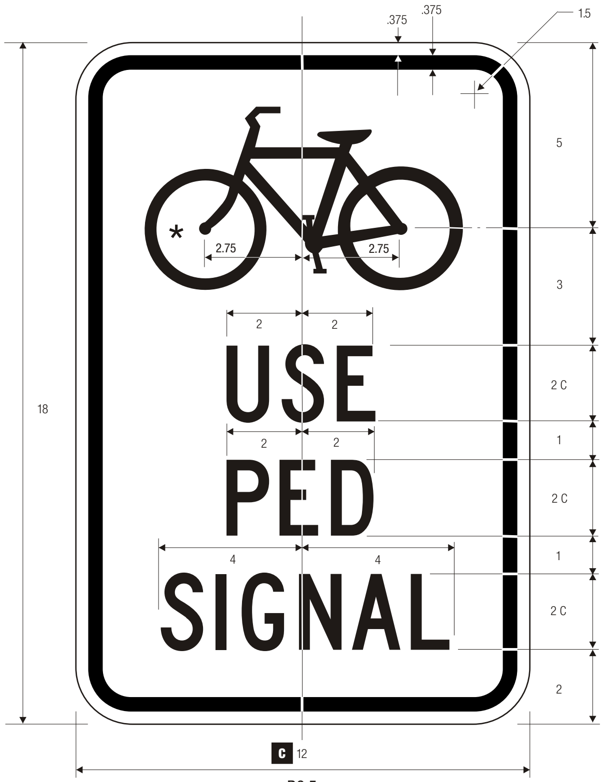


Figure 6.8 - Common Trail Signs 3
Original content by MUTCD.

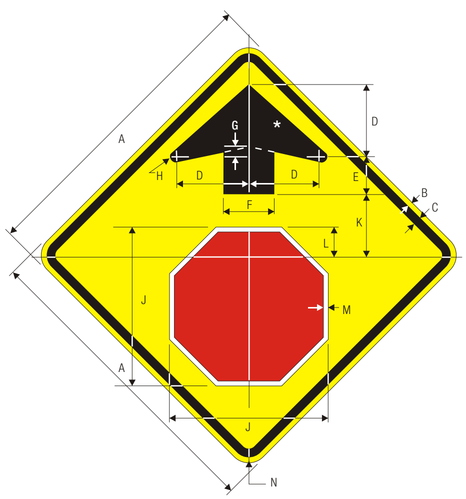


R9-5
BICYCLISTS USE PEDESTRIAN SIGNAL

*See page 6-7 for design.

R9-7
KEEP LEFT/RIGHT TO PEDESTRIANS AND BICYCLISTS

*See pages 6-7 and 6-10 for symbol design.



W3-1
STOP AHEAD

*See page 6-3 for symbol design.

A	B	C	D	E	F	G	H	J	K	L	M	N
18	.375	.625	4.5	2.25	3	.375	.187	9.5	3	1.75	.313	1.5
24	.375	.625	6	3	4	.5	.25	12.562	5	2.25	.375	1.5
30	.5	.75	7.5	3.75	5	.625	.313	15.75	6.25	2.875	.5	1.875
36	.625	.875	9	4.5	6	.75	.375	19	7.5	3.5	.625	2.25
48	.75	1.25	12	6	8	1	.5	25.125	10	4.5	.75	3

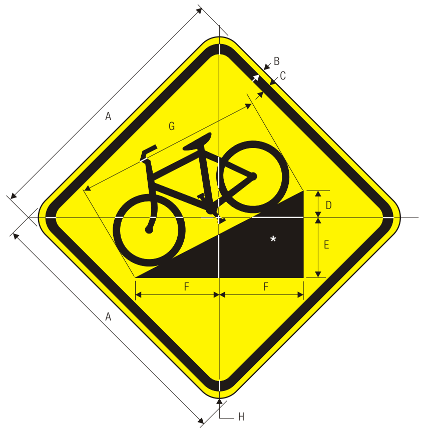
W5-4a
BIKEWAY NARROWS

*Series 2000 Standard Alphabets.

A	B	C	D	E	F	G	H	J
18	.375	.625	.625	3 C	1	6.845	7.529	1.5
30	.5	.75	1	5 C	1.813	11.406	12.545	1.875

igure 6.9 - Common Trail Signs 4

Figure 6.9 - Common Trail Signs 4
Original content by MUTCD.

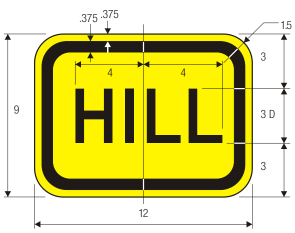


W7-5

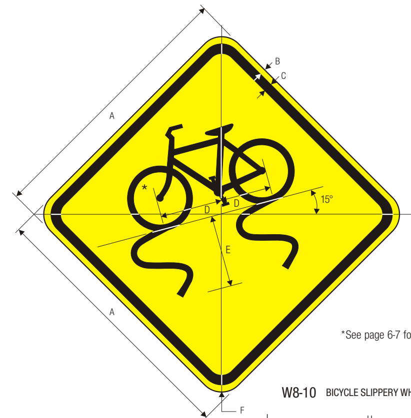
BICYCLE HILL PLAQUE

*See page 6-7 for symbol design.

A	B	C	D	E	F	G	H
18	.375	.625	1.75	4	5.625	12.625	1.5
24	.375	.625	2.3	5.3	7.5	16.833	1.5



W7-5a



*See page 6-7 for symbol design.

W8-10 BICYCLE SLIPPERY WHEN WET

W8-10a

BICYCLE SLIPPERY WHEN WET PLAQUE

**Reduce spacing 25%

A	B	C	D	E	F	G	H	J	K	L	M
18	.375	.625	3.625	4.657	1.5	12	9	.375	.375	2	2 C
24	.375	.625	4.833	6.209	1.5	24	18	.375	.625	4	4 C

N	P	Q	R	S	T	U
1.5	1.5 C	5	5.25	4.625	4.25	1.5
3	3 C	10	10.375	9	8.625	1.5

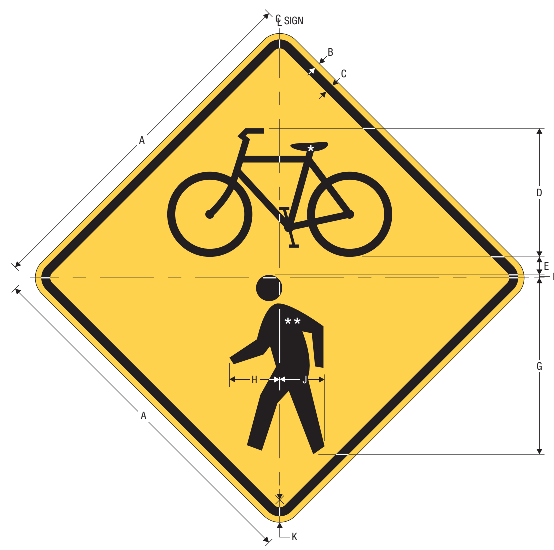
COLORS: LEGEND — BLACK
BACKGROUND — YELLOW (RETROREFLECTIVE)

W11-1

BICYCLE TRAFFIC

*See page 6-7 for symbol design.

	A	B	C	D	E	F
	18	.375	.625	5	.594	1.5
C	24	.375	.625	6.688	.813	1.5
	30	.5	.75	8.5	1	1.875
	36	.625	.875	10	1.188	2.25
	48	.75	1.25	13.375	1.625	3



W11-15

COMBINATION BIKE AND PEDESTRIAN CROSSING

* See page 6-7 for symbol design.
** See page 6-10 for symbol design.

A	B	C	D	E	F	G	H	J	K
18	0.375	0.625	6.25	1	0.125	8.875	2.524	2.25	1.5
24	0.375	0.625	8.5	1.375	0.125	11.875	3.366	3	1.5
30	0.5	0.75	10.75	1.75	0.25	14.75	4.207	3.75	1.875
36	0.625	0.875	12.75	2.125	0.375	17.625	5.049	4.5	2.25
48	0.75	1.25	17	2.75	0.375	23.625	6.732	6	3

Figure 6.10 - Common Trail Signs 5
Original content by MUTCD.
80

Figure 6.10 - Common Trail Signs 5
Original content by MUTCD.

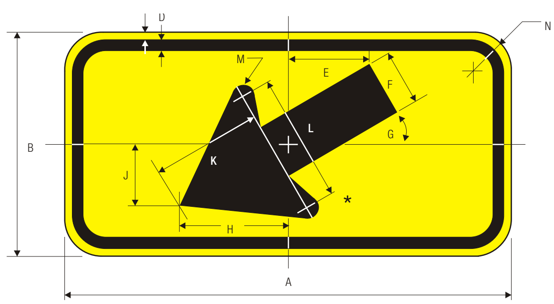
W11-15P
TRAIL CROSSING (PLAQUE)

W11-15a
TRAIL CROSSING

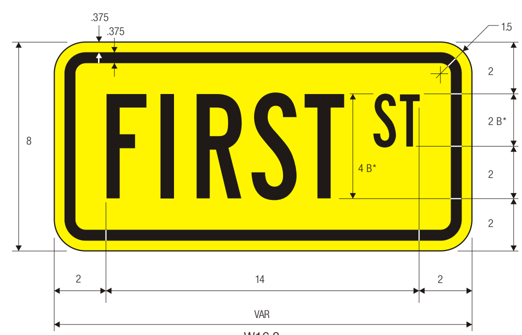
A	B	C	D	E	F	G	H	J	K	L
18	12	0.375	0.375	2.5	2.5 D	2	4.440	1.702	0.375	1.25
24	18	0.375	0.625	3.5	4 D	3	7.104	2.723	0.5	2
30	24	0.375	0.625	5	5 D	4	8.880	3.404	0.625	2.5
36	30	0.5	0.75	6.5	6 D	5	10.656	4.085	0.75	3

M	N	P	Q
0.625	0.501	4.453	1.5
1	0.852	7.074	1.5
1.25	1.063	8.845	1.5
1.5	1.277	10.612	1.875

A	B	C	D	E	F	G	H	J
24	0.375	0.625	4 C	3	5.402	6.402	10.604	1.5
30	0.5	0.75	5 C	3.75	6.877	7.878	13.255	1.875
36	0.625	0.875	6 C	4.5	8.103	9.603	15.906	2.25
48	0.75	1.25	8 C	6	10.804	12.804	21.207	3



W16-7pL
LEFT DIAGONAL ARROW PLAQUE

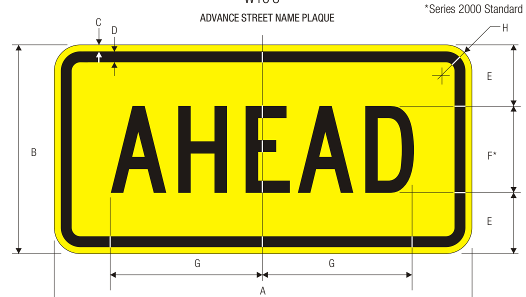


W16-8
ADVANCE STREET NAME PLAQUE

*Series 2000 Standard Alphabets.

	A	B	C	D	E	F	G	H	J	K	L	M	N
C	24	12	.375	.625	4.323	3	30°	5.844	3.282	5.884	6.925	.600	1.5
	30	18	.5	.75	6.524	4.5	30°	8.766	4.923	8.846	10.407	.920	1.875

W16-7pR
RIGHT DIAGONAL ARROW PLAQUE



W16-9p
AHEAD PLAQUE

	A	B	C	D	E	F	G	H
C	24	12	.375	.625	3.5	5 C	8.714	1.5
	30	18	.5	.75	5.5	7 C	12.201	1.875
	36	24	.625	.875	8	8 C	13.944	2.25
	48	36	.75	1.25	13	10 C	17.428	3

Figure 6.11 - Common Trail Signs 6

Figure 6.11 - Common Trail Signs 6
Original content by MUTCD.

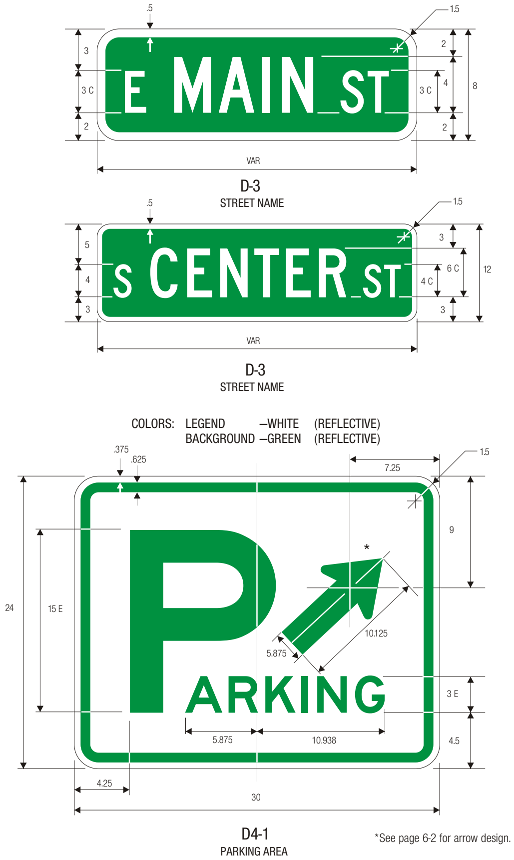
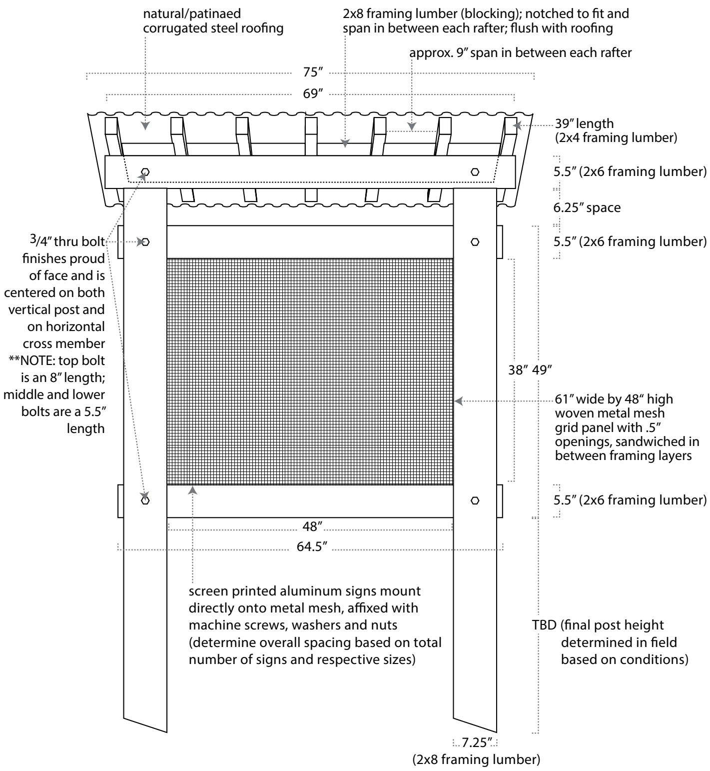
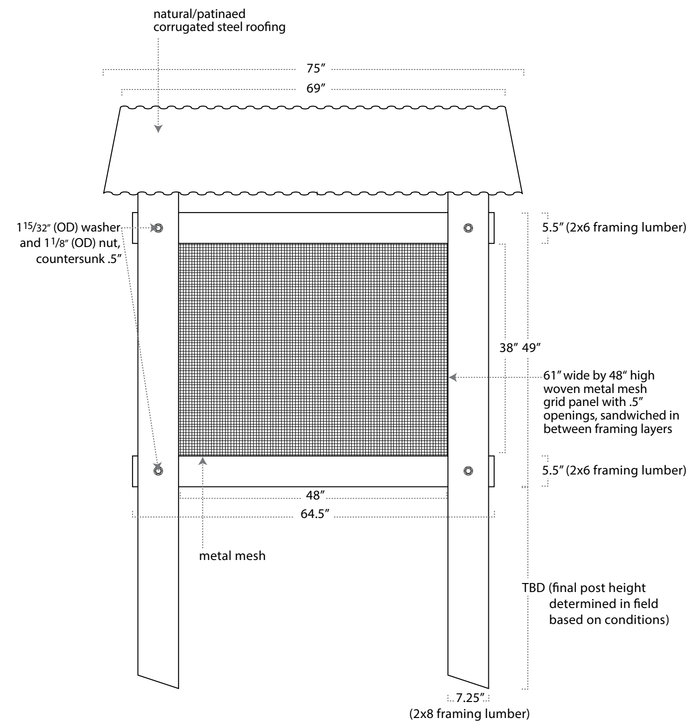


Figure 6.12 - Common Trail Signs 7
Original content by MUTCD.

6.2 Information Kiosk





Note:
This detail illustrates the current information kiosk design for Pitkin County Open Space and Trails properties. Design standard for RFTA-managed segments of the RGT Corridor TBD.

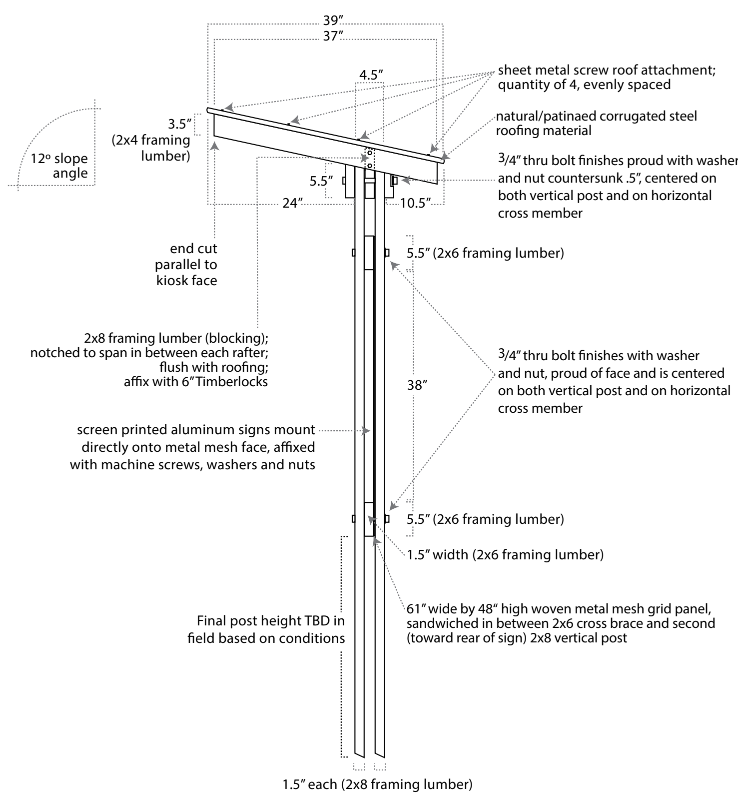


Figure 6.13 - Primary Trail Kiosk
Original detail by Pitkin County OST.

7 Weed Management and Site Revegetation/Restoration

The trail corridor passes through mostly rural and native landscapes, with zones of refined landscape character near and passing through towns along the corridor. This rural character is an important part of the experience of using the trail, and healthy native landscapes within the corridor contribute to this character. Additionally, healthy and established landscapes control erosion and the spread of invasive vegetation.

Weed Management:
The control of noxious and invasive vegetation is described in the RFTA Integrated Weed Management Policy and Plan document (IWM). That publication identifies the overarching philosophy and approach for weed management in the corridor and defines the strategic approaches for determining appropriate weed control activities within the corridor. Broadly, the IWM recommends a focus on prevention of weed invasion, improvement of soil conditions to encourage vigorous native plant growth, and mechanical control methods for weed eradication. During the planning of any project that will impact the ground surface in the corridor, consult with the Trails and Corridor Manager to understand if there are any known existing invasive weeds, or planned/ ongoing weed management activities in or near the proposed project area. Additionally, an evaluation of the physical conditions of the site is necessary to determine if noxious vegetation is present. Should significant noxious vegetation be found, a treatment program is to be included on the grading or revegetation plans associated with the improvements. Follow all relevant jurisdictional requirements for ground disturbance, weed control, and revegetation. For example, projects requiring a state Stormwater Management Plan (SWMP) Permit will submit a weed management and reclamation plan as a part of that permit. Individual weed species may have specific treatment protocol; all treatment practices are to meet the protocol of the IWM, be tailored to the targeted species, and limit the dispersion of weed seeds into the environment.

Revegetation:
Fundamentally, the implementation of improvements causing ground disturbance will require revegetation activities.
The following revegetation protocol is a general standard that will broadly apply to the corridor. Individual project location, total disturbed area, soil conditions, slope, adjacent land uses, and ecological sensitivity are to be factored into each individual revegetation project. The total restoration is comprised of four phases of work: observation, preparation, implementation, monitoring. The activities and methods described below are to be implemented as the standard unless site conditions indicate alternate methods.

Observation:
Review the physical conditions of the work area. Identify existing plant species and any noxious vegetation present. Verify that no foreign or deleterious material has been deposited in soil within a planting area.

Evaluate the soil condition and furnish a robust soil analysis by means of soil testing for nutrient quality and texture. This must include lab testing performed by a qualified independent soil-testing agency stating percentages of organic matter, inorganic matter (silt, clay, and sand), deleterious material, pH, and mineral and plant-nutrient content of topsoil. Soil samples should be taken from a minimum (4) different locations.

Preparation:
Soil is to be prepared prior to seeding. Do not mix or place soils and soil amendments in frozen, wet or muddy conditions. Suspend soil spreading, grading, and tilling operations during periods of excessive soil moisture until the moisture content reaches acceptable levels to attain the required results. Uniformly moisten excessively dry soil that is not workable and which is too dusty. Mechanically rip or disk subsoil in all areas to be planted to a minimum depth of 6-inches prior to placing top soil and soil amendments. Finish and fine grade the project area to establish an even and well matched gradient over the entire surface. Provide positive surface drainage, with no depressions, settling, or irregularities in the finished grade. At any transitional point or line where one plane intersects another, such as from a sloping area or berm to a level area, a smooth and gentle transition shall be made. Match the grades of new work with existing areas outside the project area.

Implementation:

Soil Preparation:

Loosen subgrade to a minimum of 6". Clean topsoil of roots, plants, sod, stones, clumps, and other material harmful to plant growth and the appearance of a smooth finish grade. Legally dispose of waste material. Blend planting soil before spreading, or spread topsoil, apply soil amendments and fertilizer on surface, and thoroughly blend planting soil. The recommended fertilizers are Biosol and MycoApply Endo and should be broadcast according to their manufacturer's recommendations. *Material substitutions are available and may be recommended by local or regional suppliers.*

Biosol 6-1-1 Granular: 1000 lbs./acre: As supplied by Rocky Mountain Bio-Products, Denver, Colorado, 303-696-8964 or an approved equal. Results of soil nutrient test may alter fertilizer requirements.

MycoApply Endo: 20 lbs./acre: As supplied by Rocky Mountain Bio-Products, Denver, Colorado, (303) 696-8964 or an approved equal.

Seed Application:

Timing: Seed application should occur only during the active growing season in order to achieve 4" of growth before the first killing frost. For live seeding, spring application should happen no earlier than May 15th and fall application should happen no later than September 1st. If fall seeding cannot be completed by September 1st, onsite decisions will be made, based on weather conditions and forecasts, about appropriateness of seeding in fall or the following spring. Alternately, a dormant seeding may be applied late in the season – generally mid-to-late October through December – when ground is not snow-covered. Coordinate planting periods with initial maintenance periods to provide required maintenance from date of Final Acceptance. *Broadcasting:* Seed shall be uniformly sown by broadcasting. Broadcast seeding shall be raked or chain dragged into the soil to a depth of approximately one-quarter inch (1/4") to one-half inch (½"). *Drill seeding:* Drill seeding is an appropriate substitution method for broadcasting and must be implemented by a qualified operator. Soil prep and amendments remain per this description. *Mulching:* Protect seeded areas against erosion by uniformly spreading straw mulch after completion of seeding operations. Spread uniformly at a minimum rate of 2 tons per acre (45 kg per 100 sq. m) to form a continuous blanket 1-1/2-inches (38-mm) loosen depth over seeded areas. Spread by hand, blower, or other suitable equipment. Straw mulch must be clean wheat straw mulch certified free of noxious weed seeds and having stem lengths of

6 to 10-inches on average. *Hydromulching:* hydromulching is less preferred than straw, but is acceptable where access is difficult. Apply Hydrostraw OAE at a rate of 2,000lbs/acre. Do not mix seed in hydroseeder tank.

Seed Specifics:

Typical seed mix – Pitkin County Non-irrigated Seed Mix (Pascopyrum smithii 25%, Elymus trachycaulus 25%, Pseudoregneria spicata 10%, Nassella viridula 15%, Bouteloua gracilis 15%, Achnatherum hymenoides 10%); this seed mix is available as a standard mix from local providers or may be custom-blended by other suppliers. Seed mix is to be fresh, clean, dry, new crop seed complying with the Association of Official Seed Analysts "Rules for Testing Seeds" for purity and germination tolerances.

Quantity of bulk seed required to provide the specified PLS shall be calculated from purity and germination percentage rates listed on the lot tag of seed actually purchased, using the following formulas:

Purity % multiplied by Germination % = PLS %

Lbs. PLS specified per 1000SF / PLS % = Bulk Lbs. req. per 1000SF

Application contractor to provide ‘blue tags’ (purity analysis documentation) for all seed mixes. Other seed mixes may be appropriate for specific project conditions and will be evaluated by RFTA on a case-by-case basis.

Monitoring:

Seeded areas, particularly un-irrigated native seed zones, will require several years of observation and active weed management until the seeded area is fully established. The application contractor is to coordinate with RFTA to determine the contractual obligations of monitoring and maintenance. Unless otherwise agreed upon between RFTA and the application contractor, the minimum standard for final acceptance and the beginning of the warranty period is as follows: At the end of one growing season, all seeded areas shall achieve 85% germination and be free of weeds and other undesirable vegetation. Use specified materials to reestablish seeding areas that do not comply with requirements and continue maintenance until establishment is satisfactory. The application contractor is obligated to maintain the seeded area until final acceptance is achieved.